Tektronix®
COMMITTED TO EXCELLENCE

PLEASE CHECK FOR CHANGE INFORMATION AT THE REAR OF THIS MANUAL.

FG 501A 2 MHz FUNCTION GENERATOR

Francais Deutsch 日本語

INSTRUCTION MANUAL

Tektronix, Inc.
P.O. Box 500
Beaverton, Oregon 97077

070-2957-00
Product Group 75

Serial Number ____________

First Printing AUG 1980
Revised APR 1986

TABLE OF CONTENTS

TABLE OF CONTENTS (cont)

LIST OF ILLUSTRATIONS

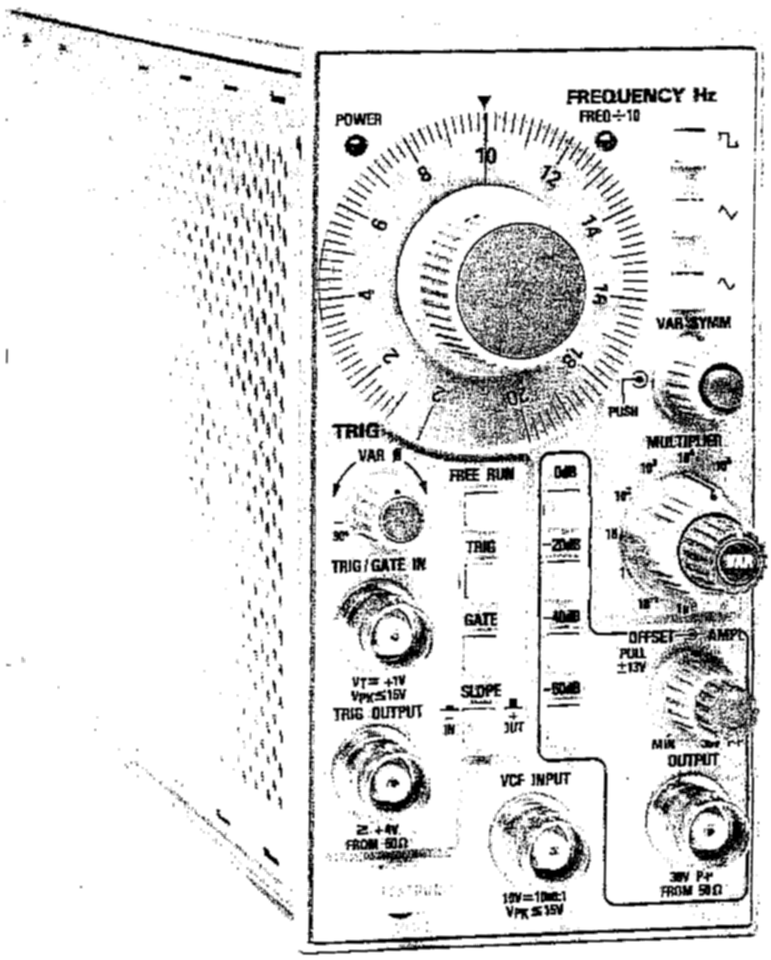
NOTE

The following illustrations appear in the Diagrams and Illustrations foldout section.

LIST OF TABLES

NOTE

The following tables appear in the Diagrams and Illustrations foldout section.



2957-00

FG 501A 2 MHz FUNCTION GENERATOR

SPECIFICATION

INTRODUCTION

This section of the manual contains a general description of the FG 501A and complete electrical, environmental, and physical specifications. Standard accessories are also listed. Instrument option information is located in the back of this manual in a separate section.

INSTRUMENT DESCRIPTION

The FG 501A Function Generator provides low distortion sine, square, triangle, ramp, and pulse waveforms over the frequency range 0.002 Hz to 2 MHz in eight decade steps. Dc offset up to ±13 V is available. Waveform triggering and gating functions, in addition to being slope (+ or −) selectable, are provided with variable phase control capable of up to ±90° phase shift. The symmetry of the output waveform may also be varied from 5 to 95%. Step attenuators provide up to 60 dB of attenuation in 20 dB steps. A variable amplitude control provides an additional 20 dB attenuation.

A voltage-controlled frequency (VCF) input is provided to control the output frequency from an external voltage source. The output frequency can be swept above and below the selected frequency to a maximum of 1000:1 depending on the polarity and amplitude of the VCF input signal and the selected output frequency.

ACCESSORIES

The only accessory shipped with the FG 501A is the Instruction Manual.

PERFORMANCE CONDITIONS

The electrical characteristics are valid with the following conditions:

1. The instrument must have been adjusted at an ambient temperature between +20°C and +30°C and operating at an ambient temperature between 0°C and +50°C.

2. The instrument must be in a non-condensing environment whose limits are described under Environmental.

3. Allow twenty minutes warm-up time for operation to specified accuracy; sixty minutes after exposure to or storage in high humidity (condensing) environment.

Items listed in the Performance Requirements column of the Electrical Characteristics are verified by completing the Performance Check in this manual. Items listed in the Supplemental Information column may not be verified in this manual; they are either explanatory notes or performance characteristics for which no limits are specified.

Table 1-1

ELECTRICAL CHARACTERISTICS

Characteristics	Performance Requirements	Supplemental Information
Frequency Range		Provided in eight decade steps plus variable, with overlap on all ranges.
Sine-wave, square-wave, and triangle	.002 Hz to 2 MHz	Calibrated portion of dial extends from 20 to 2. Portion of dial from 2 to .2 is uncalibrated .0002 Hz to .002 Hz uncalibrated portion of dial.
Ramp and Pulse	.002 Hz to 200 kHz ±10% calibrated portion of dial.	Measured at 50% duty cycle. .0002 Hz to .002 Hz uncalibrated portion of dial.
Variable Symmetry Duty Cycle	⩽5% to ⩾95%.	Activation of Symmetry control divides output frequency by ≈10.
Output Amplitude	At least 30 V P-P into an open circuit, at least 15 V p-p into 50 Ω. (Front panel only.)	Offset control off.
Output Impedance		Front panel z_o = 50 Ω ±10%. ATTEN in 0 dB position. Rear interface z_o = 600 Ω −10%.
Offset Range	At least ±13 V into open circuit, at least ±6.5 V into 50 Ω. Maximum peak signal plus offset cannot exceed ±15 V into an open circuit, or ±7.5 into 50 Ω. (Front panel only.) Offset reduced by attenuators.	
Frequency Resolution		1 part in 10^4 of full scale with frequency vernier control.
Stability (Frequency) Time		⩽0.1% for 1 hour, ⩽0.5% for 24 hours.
Temperature		Within 2% from .2 Hz to 2 MHz, and within 10% from .002 Hz to .2 Hz. The FREQUENCY Hz dial must be on the calibrated portion. The instrument must be in a temperature between 0° C and +50° C and checked after a 1 hour warmup. VAR SYMM control disabled.

Table 1-1 (cont)

Characteristics	Performance Requirements	Supplemental Information
Amplitude Flatness	Measured with 0 dB ATTEN button "IN" and output driving 50 Ω load. (Front panel only.)	
Sinewave (10 kHz Sinewave Ref)	±0.1 dB 20 Hz to 20 kHz	Typically ±.5 dB .002 Hz to 20 Hz.
	±0.5 dB 20 kHz to 1 MHz	
	±1 dB 1 MHz to 2 MHz	
Squarewave (10 kHz Squarewave Ref)	Peak to peak amplitude within ±0.5 dB of squarewave reference amplitude 20 Hz to 2 MHz.	Typically within ±.5 dB .002 Hz to 20 Hz.
Triangle (10 kHz Triangle Ref)	Peak to peak amplitude within ±0.5 dB of triangle wave reference amplitude 20 Hz to 200 kHz. Within 2 dB 200 kHz to 2 MHz.	Typically within ±.5 dB .002 Hz to 20 Hz.
Sinewave Distortion	⩽0.25% 20 Hz to 20 kHz on 10^3 range and below.	20° to 30° C. Measured with with average responding THD meter. Measurement bandwidth limited to approximately 300 kHz.
	⩽0.5% 20 kHz to 100 kHz.	Verified at 15 V p-p into 50 Ω load. Must be on calibrated portion of dial. VAR SYMM control off. Offset control off.
	All harmonics at least 30 dB below fundamental from 100 kHz to 2 MHz.	Trig output driving open circuit.
Squarewave Output	Step ATTEN in 0 dB position.	
Risetime and Falltime	⩽25 ns at 15 V p-p into 50 Ω.	
Aberrations (p-p)	⩽3% (Front panel only.)	
Pulse Output	Step ATTEN in 0 dB position.	
Risetime and Falltime	⩽25 ns at 15 V p-p into 50 Ω.	
Aberrations (p-p)	⩽3% (Front panel only.)	
VCF Input	10 V ⩾1000:1	Applicable within the range of top dial frequency to top dial frequency/1000. Positive going voltage increases frequency. Maximum Slew Rate = 0.5 V/μs. Maximum input ⩽15 V pk.
Ext Trig/Gate Input		
Impedance		≈2 kΩ
Threshold Level	+1 V ±20%.	Maximum input ⩽ 15 V pk.
Trigger Output	⩾ +4 V into open circuit. ⩾ +2 V into 50 Ω.	
Variable Phase Range	At least ±90°	Sine and Triangle only.

Table 1-1 (cont)

Characteristics	Performance Requirements	Supplemental Information
Attenuators		60 dB in 20 dB steps. >20 dB additional attenuation with amplitude control.
Accuracy	±1 dB.	Verified at 20 kHz.
Dial Accuracy	Within 3% of full scale, 20 to 12, except within 5% between 0° and 15°C and 35° and 50°C on the 10^5 Multiplier Range.	2 to .2 Uncal.
Triangle		
Linearity		Greater than or equal to 99% 20 Hz to 200 kHz. 97% 200 kHz to 2 MHz (calibrated). Measured from 10% to 90% of waveform.
Time Symmetry	Better than 1% 20 Hz to 200 kHz. 5% 200 kHz to 2 MHz (calibrated).	

Table 1-2

MISCELLANEOUS

Characteristics	Description
Power Consumption	12 W or less. (Plug-in only)
Recommended Adjustment Interval	1000 hours or 6 months, whichever occurs first.
Warm-up Time	20 minutes.

Table 1-3

ENVIRONMENTAL[a]

Characteristics	Description	
Temperature		Meets MIL-T-28800B, class 5.
Operating	0°C to +50°C	
Non-operating	−55°C to +75°C	
Humidity	95% RH, 0°C to 30°C 75% RH to 40°C 45% RH to 50°C	Exceeds MIL-T-28800B, class 5.
Altitude		Exceeds MIL-T-28800B, class 5.
Operating	4.6 Km (15,000 ft)	
Non-operating	15 Km (50,000 ft)	
Vibration	0.38 mm (0.015") peak to peak, 5 Hz to 55 Hz, 75 minutes.	Exceeds MIL-T-28800B, class 5, when installed in qualified power modules.[b]

Table 1-3 (cont)

Characteristics	Description	
Shock	30 G's (1/2 sine), 11 ms duration, 3 shocks in each direction along 3 major axes, 18 total shocks.	Meets MIL-T-28800B, class 5, when installed in qualified power modules.[b]
Bench Handling[c]	12 drops from 45°, 4" or equilibrium, whichever occurs first.	Meets MIL-T-28800B, class 5.
Transportation[c]	Qualified under National Safe Transit Association Preshipment Test Procedures 1A-B-1, and 1A-B-2.	
EMC	Within limits of MIL-461A, and F.C.C. Regulations, Part 15, Subpart J, Class A.	
Electrical Discharge	20 kV maximum charge applied to instrument case.	

[a] With power module.

[b] Refer to TM 500 power module specifications.

[c] Without power module.

Table 1-4

PHYSICAL CHARACTERISTICS

Characteristics	Description
Finish	Plastic/aluminum laminate front panel. Anodized aluminum chassis.
Net Weight	1.88 lbs (.85 kg)
Overall Dimensions	Height 5 in (126mm) Width 2.6 in (67mm) Length 11.9 in (303mm)

OPERATING INSTRUCTIONS

INTRODUCTION

This section of the manual provides operating information required to obtain the most effective performance from the FG 501A. Included are installation and removal instructions, a functional description of the front panel controls, and a general description of the operating modes. Some basic applications of the instrument are also briefly discussed.

INSTALLATION AND REMOVAL

The FG 501A is calibrated and ready to use when received. It operates in one compartment of any TM 500-series power module. Refer to the power module instruction manual for line voltage requirements and power module operation.

CAUTION

To prevent damage to the FG 501A, turn the power module off before installation or removal of the instrument from the mainframe. Do not use excessive force to install or remove.

Check to see that the plastic barriers on the interconnecting jack of the selected power module compartment match the cutouts in the FG 501A circuit board edge connector. If they do not match, do not insert the instrument until the reason is found. When the units are properly matched, align the FG 501A chassis with the upper and lower guides of the selected compartment (see Fig. 2-1). Insert the FG 501A into the compartment and press firmly to seat the circuit board edge connector in the power module interconnecting jack. Apply power to the FG 501A by operating the power switch on the power module.

To remove the FG 501A from the power module, pull the release latch (located in the lower left corner) until the interconnecting jack disengages. The FG 501A will now slide straight out.

REPACKAGING FOR SHIPMENT

If the Tektronix instrument is to be shipped to a Tektronix Service Center for service or repair, attach a tag showing: owner (with address) and the name of an individual at your firm that can be contacted. Include complete instrument serial number and a description of the service required.

If the original package is not fit for use or not available, repackage the instrument as follows:

Surround the instrument with polyethelene sheeting, or other suitable material, to protect the exterior finish. Obtain a carton of corrugated cardboard of adequate strength and having inside dimensions no less than six inches more than the instrument dimensions. Cushion the instrument by tightly packing dunnage or urethane foam between the carton and the instrument, on all sides. Seal the carton with shipping tape or an industrial stapler.

The carton test strength for your instrument is 200 pounds.

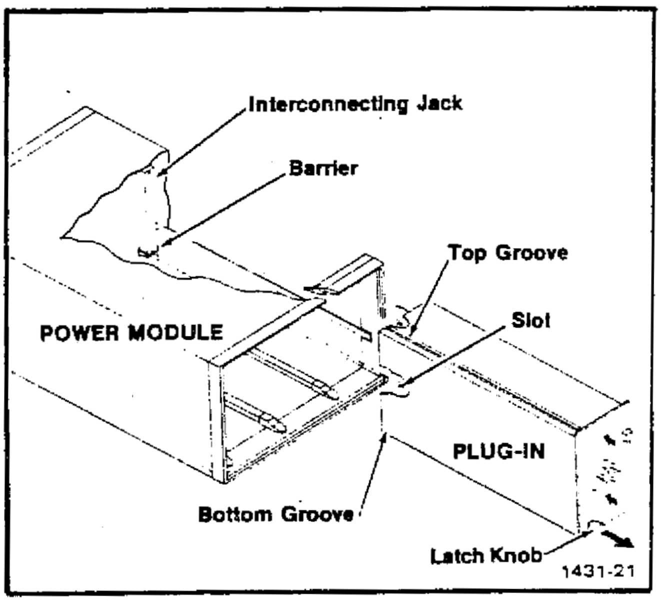
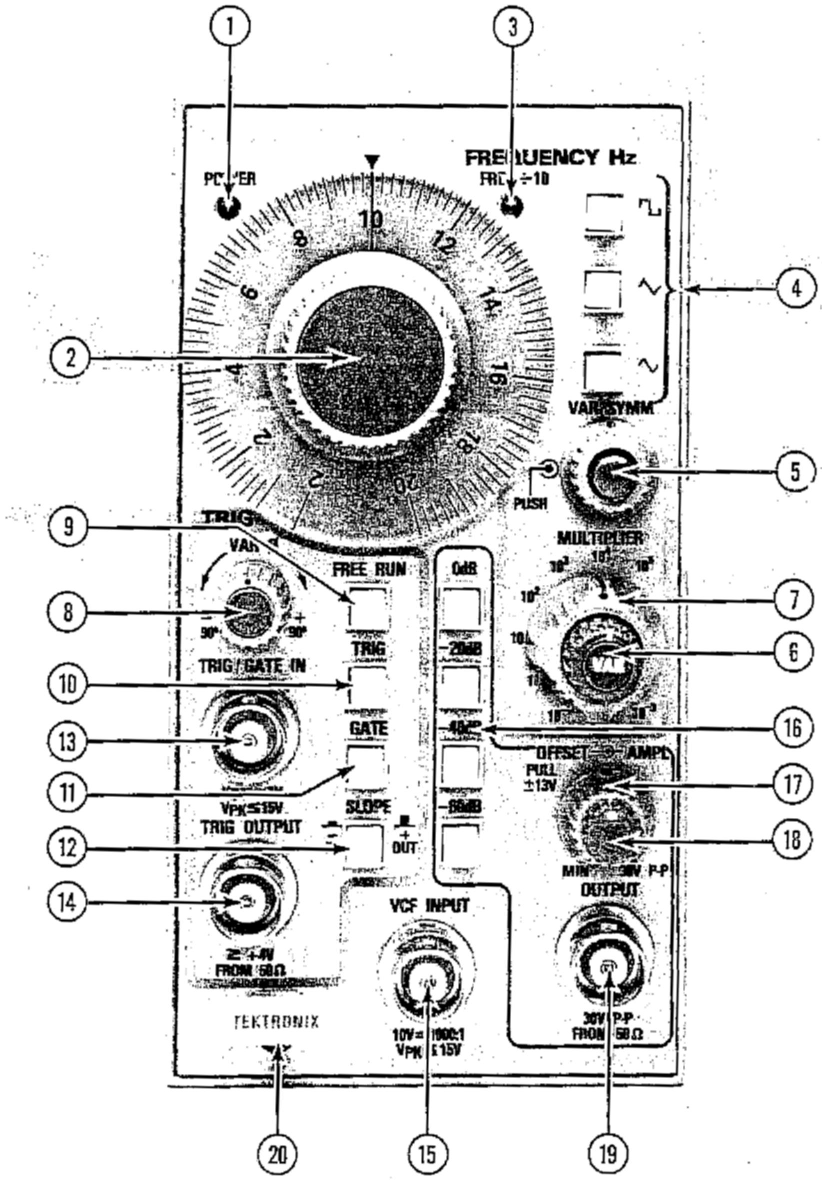


Fig. 2-1. Plug-in installation and removal.

CONTROLS AND CONNECTORS

Although the FG 501A is calibrated and ready to use, the functions and actions of the controls and connectors should be reviewed before attempting to use it. All controls necessary for operation of the instrument are located on the front panel. A brief description of these controls follows. Refer to Fig. 2-2.



2957-01

Fig. 2-2. Controls and connectors.

(1) **POWER**—Illuminated when power is applied to the FG 501A.

FREQUENCY CONTROL AND FUNCTION SELECTION

(2) **FREQUENCY Hz**—Selects the frequency of the output waveform in conjunction with the MULTIPLIER control.

(3) **FREQ ÷ 10**—Illuminated when the variable symmetry function is activated.

(4) **FUNCTION BUTTONS**—Select square, triangle, and sine waveforms.

(5) **VAR SYMM**—(push to enable) adjusts time-based symmetry of the selected output waveform. Reduces the frequency of the output waveform by a factor ≈ 10 and illuminates the FREQ ÷ 10 indicator.

(6) **FREQUENCY VERNIER**—For fine adjustment of output frequency to at least 1 part in 10^4 of full scale.

(7) **MULTIPLIER**—Selects the output frequency in eight decade steps in conjunction with the FREQUENCY Hz control.

TRIGGER AND GATE CONTROLS

(8) **VAR Ø**—Selects phase lead or lag, up to ±90°, relative to input trigger or gate waveform.

(9) **FREE RUN**—When pressed causes continuous waveform output.

(10) **TRIG**—When pressed causes output of one cycle of selected waveform for each trigger pulse applied to the TRIG/GATE IN connector.

(11) **GATE**—When pressed causes continuous output of the selected waveform for the duration of the gating pulse.

(12) **SLOPE**—Button selects, in TRIG mode, the slope of the input signal which will trigger the selected output waveform. In GATE mode, whether output gating will occur when the level of the input signal is above or below the threshold level of +1 V.

(13) **TRIG/GATE IN**—Bnc connector used to apply the external trigger or gating signal.

(14) **VCF INPUT**—Bnc connector for applying an external voltage for controlling the output frequency of the generator.

(15) **TRIGGER OUTPUT**—Bnc connector which outputs one positive pulse for each cycle of the selected output waveform.

OUTPUT CONTROLS

(16) **ATTENUATOR BUTTONS**—Attenuate the amplitude of the selected output waveform in 20 dB steps to a maximum of 60 dB when pressed.

(17) **AMPL**—Varies the amplitude of the selected output waveform, between steps of the attenuator buttons.

(18) **OFFSET**—Pull and turn control, concentric with the AMPL control, provides up to ±13 V dc offset of the output waveform.

(19) **OUTPUT**—Bnc connector for output of the selected waveform.

(20) **RELEASE LATCH**—Pull to disengage the FG 501A from the power module.

OPERATING CONSIDERATIONS

OUTPUT CONNECTIONS

The output of the FG 501A is designed to operate as a 50 Ω voltage source working into a 50 Ω load. At higher frequencies, an unterminated or improperly terminated output will cause aberrations on the output waveform. Loads less than 50 Ω will reduce the waveform amplitude.

Excessive distortion or aberrations, due to improper termination, are less noticeable at the lower frequencies (especially with sine and square waveforms). To ensure waveform purity, observe the following precautions:

1. Use good quality 50 Ω coaxial cables and connectors.

2. Make all connections tight and as short as possible.

3. Use good quality attenuators if it is necessary to reduce waveform amplitude applied to sensitive circuits.

4. Use terminations or impedance matching devices to avoid reflections when using long cables (6 feet or more).

5. Ensure that attenuators, terminations, etc. have adequate power handling capabilities for the output waveform.

If there is a dc voltage across the output load, use a coupling capacitor in series with the load. The time constant of the coupling capacitor and load must be long enough to maintain pulse flatness.

RISETIME AND FALLTIME

If the FG 501A is used to measure the rise or falltime of a device, the riestime characteristics of associated equipment should be considered. If the risetime of the device under test is at least 10 times greater than the combined risetimes of the FG 501A and associated equipment, the error introduced will not exceed 1%, and generally can be ignored. When the rise or falltime of the test device is less than 10 times as long as the combined risetimes of the testing system, the actual risetime of the system must be calculated. The risetime of the device under test can be determined once the risetime of the system is known.

IMPEDANCE MATCHING

If the FG 501A is driving a high impedance such as the 1 MΩ input impedance (paralleled by a stated capacitance) of the vertical input of an oscilloscope, connect the transmission line to a 50 Ω attenuator, 50 Ω termination, and then to the oscilloscope input. The attenuator isolates the input capacitance of the device, and the FG 501A is properly terminated.

FIRST TIME OPERATION

The Controls and Connectors pages give a description of the front panel controls and connectors. The waveform selection and frequency determining controls are outlined in blue, the trigger function controls and inputs are outlined in green, and the output controls are outlined in black.

The following exercise will familiarize the operator with most functions of the FG 501A.

NOTE

If any discrepancies are encountered during the exercise, refer the condition to qualified service personnel.

Preset the controls as follows:

Blue section:

FREQUENCY Hz	10
MULTIPLIER	10^2
FREQUENCY VERNIER	Fully cw
WAVEFORM—SINE	in
VAR SYMM	off

Green section:

FREE RUN	in

Black section:

ATTENUATOR	−20 dB
AMPL (variable)	Centered
OFFSET	off

Connect a 50 Ω bnc coaxial cable terminated in 50 Ω to the vertical input of an oscilloscope. Set the oscilloscope controls to:

Vertical	1 V/Div DC Coupled
Horizontal (Time Base)	1 ms/Div

The oscilloscope should display 1 complete cycle per division of the sine waveform (approximately 10 cycles across the graticule).

@

1. Alternately press the square, triangle and sine buttons and observe the different waveshapes. Return to the preset condition.

2. Alternately press the four attenuator buttons and rotate the AMPL (variable) control to verify that the waveform amplitude changes. Return these controls to the preset condition.

3. Pull the OFFSET knob out and rotate it. Notice the change in dc level of the displayed waveform. Return the OFFSET knob to the in position.

4. Push the VAR SYMM button to release it to the out position. Observe that the FREQ ÷ 10 indicator is illuminated and only one cycle of the output waveform is displayed. Rotate the VAR SYMM control through its range and notice the change in shape of the square, triangle, and sine waveforms (with the appropriate buttons pushed in). Return the controls to the preset condition.

5. Rotate the FREQUENCY control and the MULTIPLIER switch while observing the change in frequency of the displayed waveform. Return these controls to the preset condition.

OPERATING MODES

FREE-RUNNING OUTPUT

The following procedure will provide a free-running output with variable frequency and amplitude.

1. Select the desired waveform.

2. Set the AMPL control fully counterclockwise. Check that the VAR SYMM and OFFSET controls are in the off (in) position.

3. Select the desired frequency with the FREQUENCY Hz dial and MULTIPLIER switch. Frequency equals dial setting times multiplier setting.

4. Connect the load to the FG 501A output connector and adjust the AMPL control for the desired output amplitude.

TRIGGERED OR GATED (BURST) OPERATION

With the FG 501A set for free-running operation, as described in previous paragraphs, apply the triggering or gating signal to the TRIG/GATE IN connector.

If only one cycle of the output waveform per trigger is desired, push the TRIG button and select + or − slope. One output cycle will now be generated for each input trigger cycle.

If more than one cycle of the output waveform is desired, push the GATE button. The output will now be continuous for the duration of the gating waveform. The number of cycles per burst can be approximated by dividing the gating signal duration by the period of FG 501A output frequency.

In triggered or gated operation the PHASE control varies the start of the output waveform by ±90°. This phase change is measured from the 0 V, 0° point on the output waveform.

VOLTAGE CONTROLLED FREQUENCY (VCF) OPERATION

The output frequency of any selected waveform can be swept within a range of 1000:1 by applying an external voltage to the VCF INPUT connector. The polarity of the VCF input signal determines which direction the output frequency sweeps from the selected frequency. A positive (+) going signal increases the frequency while a negative (−) going signal decreases the frequency. The amplitude and polarity of the input voltage can be selected within a range of ±10 V depending on the FREQUENCY Hz dial setting.

The maximum swept frequency range of 1000:1 encompasses the uncalibrated portion of the FREQUENCY Hz dial (< .2 to 2). To ensure that the frequency does sweep at least a range of 1000:1, it is recommended that the FREQUENCY Hz dial be set at .2 and a 0 to +10 V signal be applied to the VCF INPUT connector. It may be necessary to vary the FREQUENCY VERNIER control to obtain the full 1000:1 swept range or the lowest swept frequency desired.

Since the VCF input amplitude is a linear relationship, the frequency output range can be determined from the VCF input amplitude.

TRIGGER OUTPUT

A +4 V square wave is available from the TRIG OUTPUT connector. The frequency of the trigger output is determined by the frequency of the selected output waveform. One trigger pulse is generated for each positive cycle of the output signal except when square waves are selected. When generating square waves, one trigger pulse is generated for each negative cycle of the output signal. Trigger output impedance is 50 Ω.

BASIC WAVEFORM CAPABILITIES

The following photographs illustrate the basic waveform capabilities of the FG 501A.

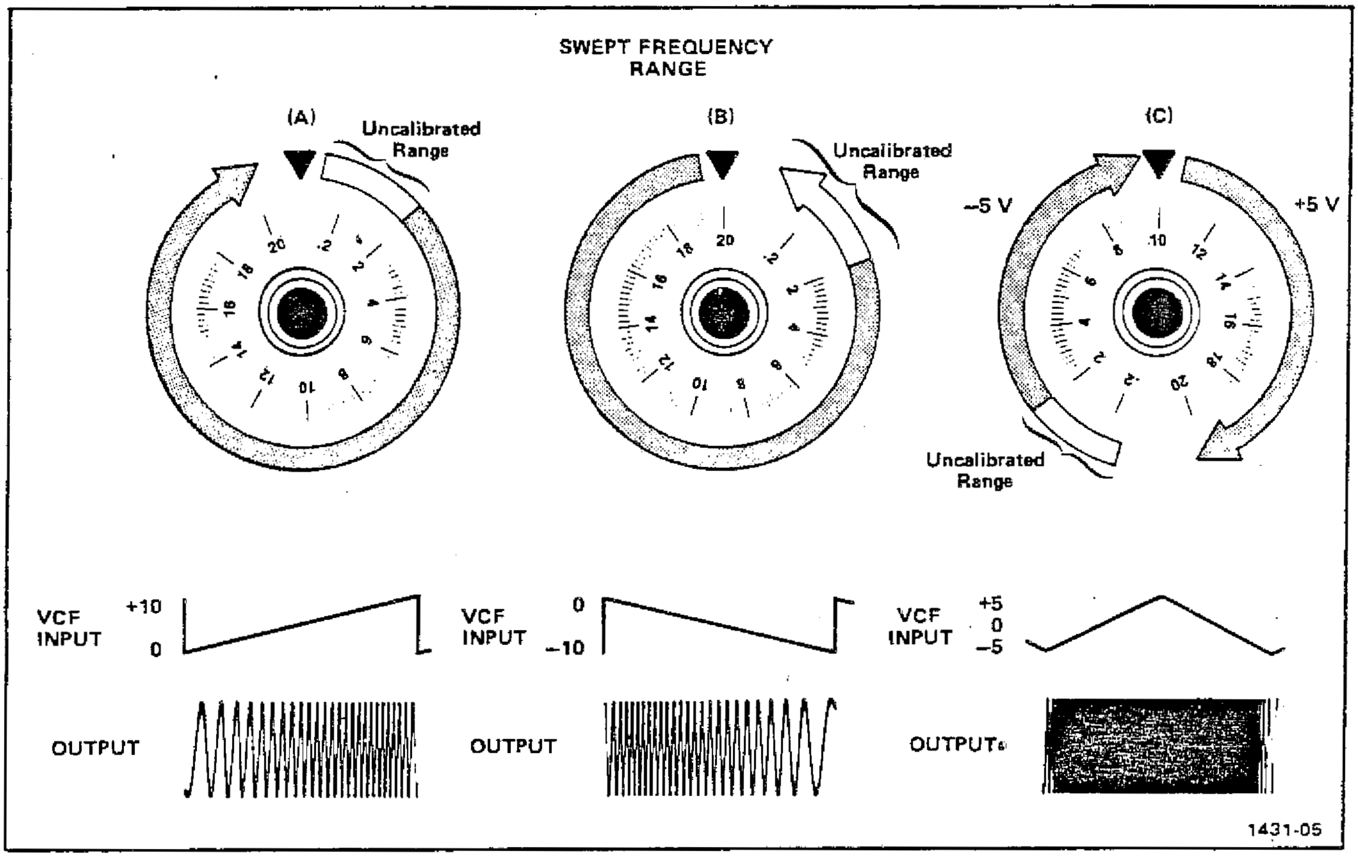


Fig. 2-3. Swept Frequency range with 10 V signals applied to VCF IN connector.

@

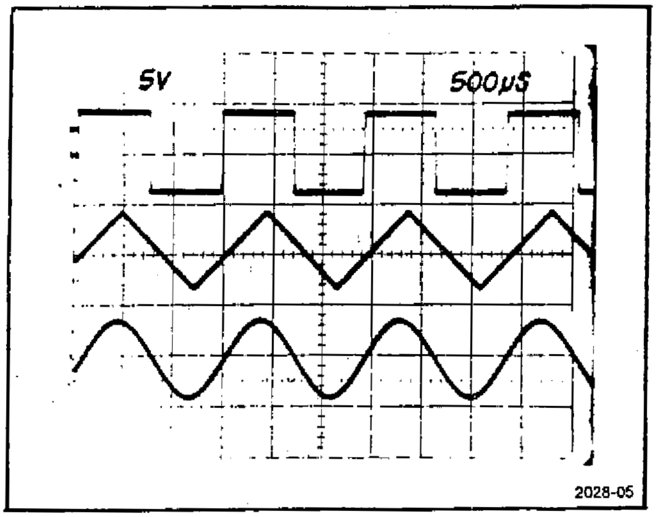


Fig. 2-4. BASIC FUNCTIONS. Square, triangle, and sine waveforms selected by front panel pushbuttons.

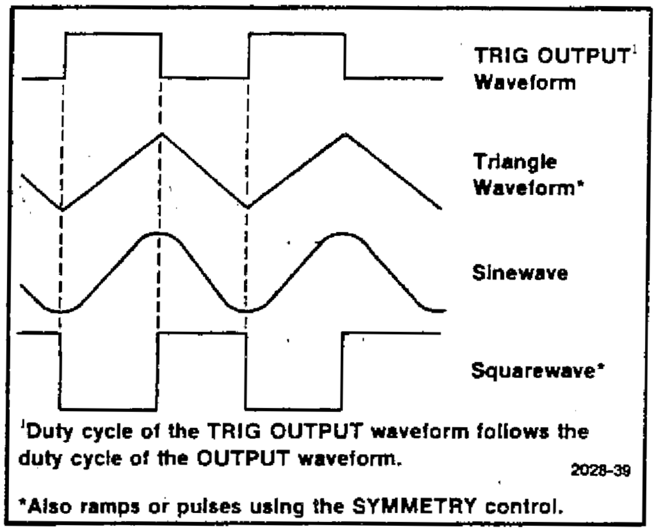


Fig. 2-6. Phase relationships between OUTPUT waveforms and the TRIG OUT waveform.

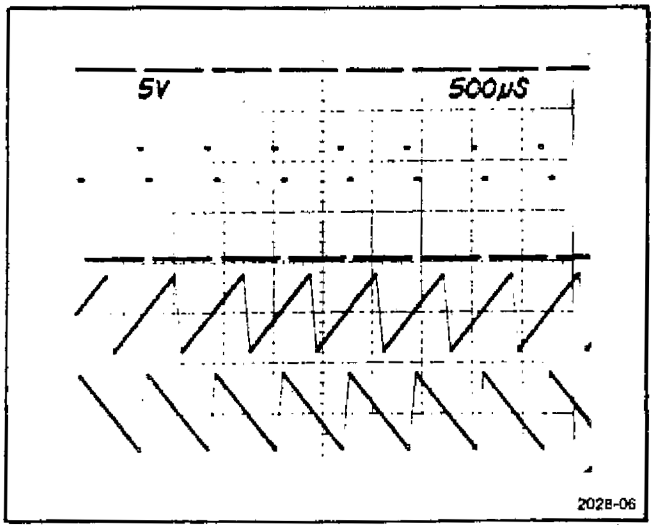


Fig. 2-5. RAMPS AND PULSES. These are obtained from the basic waveforms by using the SYMMETRY control.

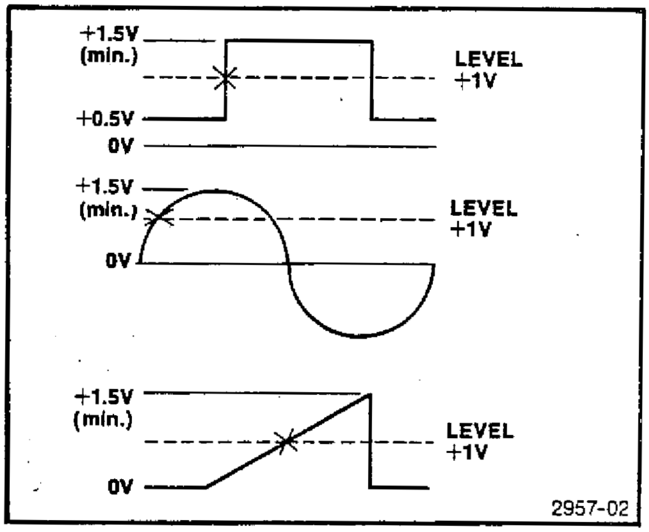


Fig. 2-7. Trigger Signal amplitude requirements and triggering points.

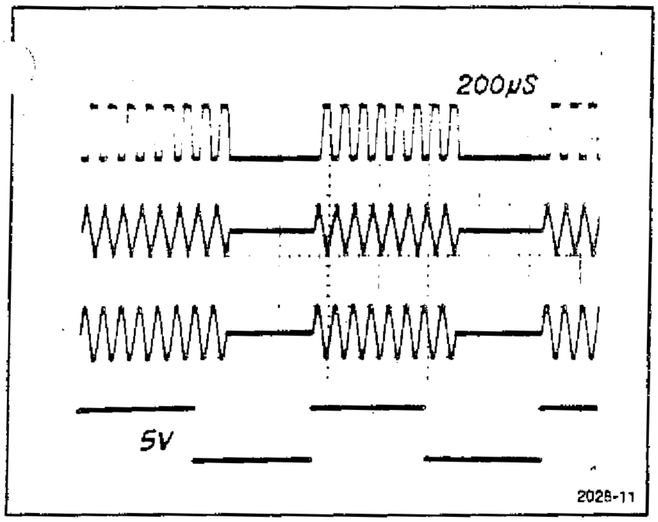


Fig. 2-8. GATED OPERATION. The top three traces are various output waveforms and the bottom trace is the gating waveform applied to the trigger INPUT connector with the GATE pushbutton pressed in. Note the additional cycle completed after the waveforms are gated off.

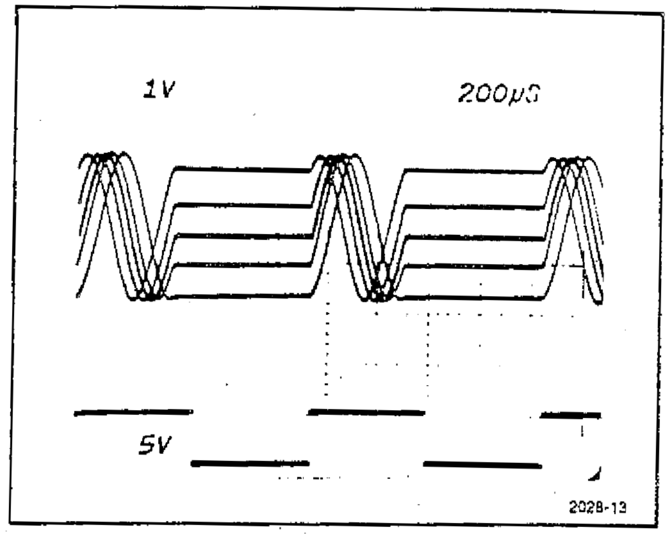


Fig. 2-10. PHASE CONTROL OPERATION. This photograph illustrates PHASE control usage in the triggered mode. The five super-imposed traces illustrate the effect of the phase control. This control provides ±90° of shift. The bottom trace is the triggering waveform.

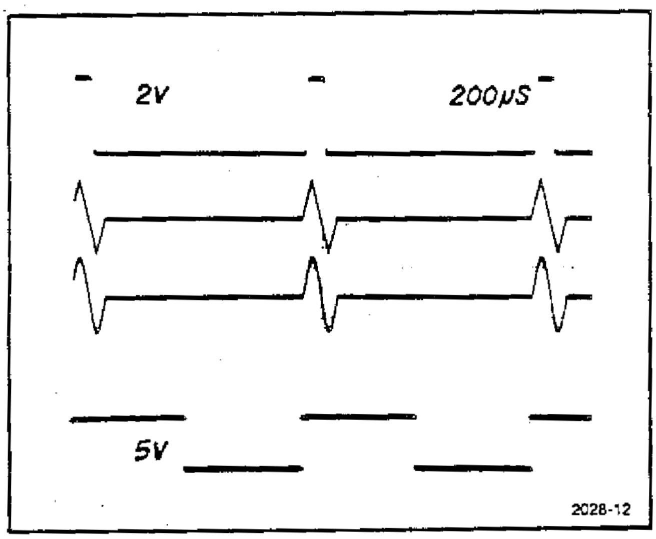


Fig. 2-9. TRIGGERED OPERATION. The top three traces are the various output traces selected. The bottom trace is the triggering waveform applied to the trigger INPUT connector with the TRIG mode selected. Note that only one cycle of the output waveforms is completed.

APPLICATIONS

RESPONSE ANALYSIS

The FG 501A is particularly suited for determining response characteristics of circuits or systems. This application utilizes the VCF input of the FG 501A to sweep the generator over a range of frequencies. Refer to the Voltage Controlled Frequency (VCF) Operation discussion under Operating Modes for additional information.

1. Connect the equipment as shown in Fig. 2-11.

2. Set the MULTIPLIER selector and FREQUENCY Hz dial for the desired upper or lower frequency limit (depending on the direction you wish to sweep).

3. Apply the desired waveform to the VCF INPUT connector. (A positive-going waveform will increase the frequency while a negative-going waveform will decrease it.)

4. Adjust the amplitude of the VCF input waveform for the desired output frequency range.

5. Observe the response characteristics on the monitoring oscilloscope.

The frequency at which a displayed response characteristic occurs can be determined by first removing the VCF input waveform, then manually adjusting the FREQUENCY Hz dial to again obtain the particular characteristic observed in the swept display and reading that frequency on the FREQUENCY Hz dial.

TONE-BURST GENERATION OR STEPPED FREQUENCY MULTIPLICATION

The FG 501A can be used as a tone-burst generator or frequency multiplier for checking tone-controlled devices. This application utilizes a ramp generator, such as the TEKTRONIX RG 501, as a VCF signal source and a pulse generator, such as the TEKTRONIX PG 501, as a gating signal source.

The following procedure describes a technique for obtaining a tone-burst or frequency multiplied output

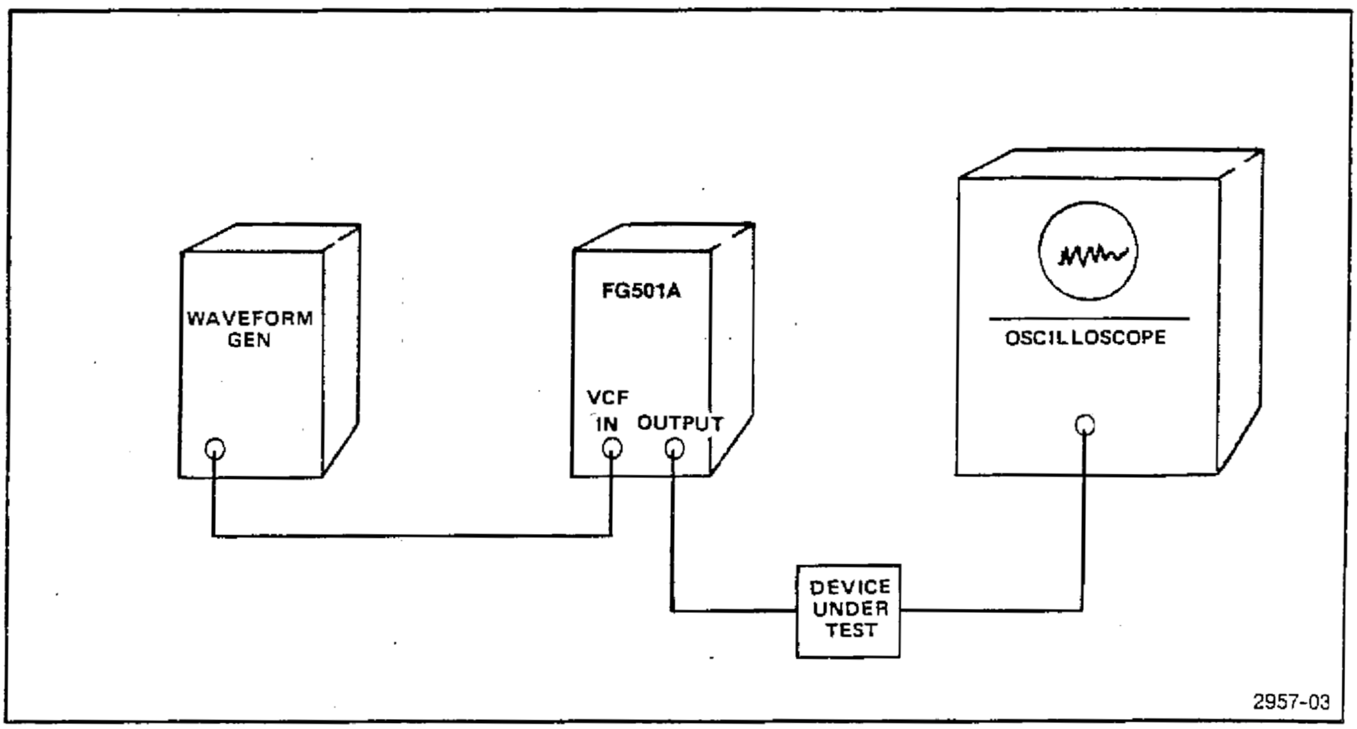


Fig. 2-11. Analyzing circuit or system response.

from the FG 501A. Refer to the Gated (burst) Output and Variable Phase and the Voltage-controlledFrequency (VCF) Output discussions under Operation for additional information.

1. Connect the equipment as shown in Fig. 2-12.

2. Push the GATE button in and set the PHASE control to the desired phase.

3. Set the ramp generator for the desired ramp duration and polarity.

4. Adjust the pulse generator period for the desired number of bursts within the selected ramp duration. Adjust the pulse generator duration for the desired burst width.

5. Select the sweep frequency range by adjusting the FREQUENCY Hz dial for one end of the sweep range (upper or lower limit depending on the polarity of the ramp). Then, adjust the ramp generator amplitude for the other swept frequency limit.

Various other tone-burst or frequency multiplie characteristics can be obtained by using different gatin input waveforms, i.e., triangle, sine, square, etc.

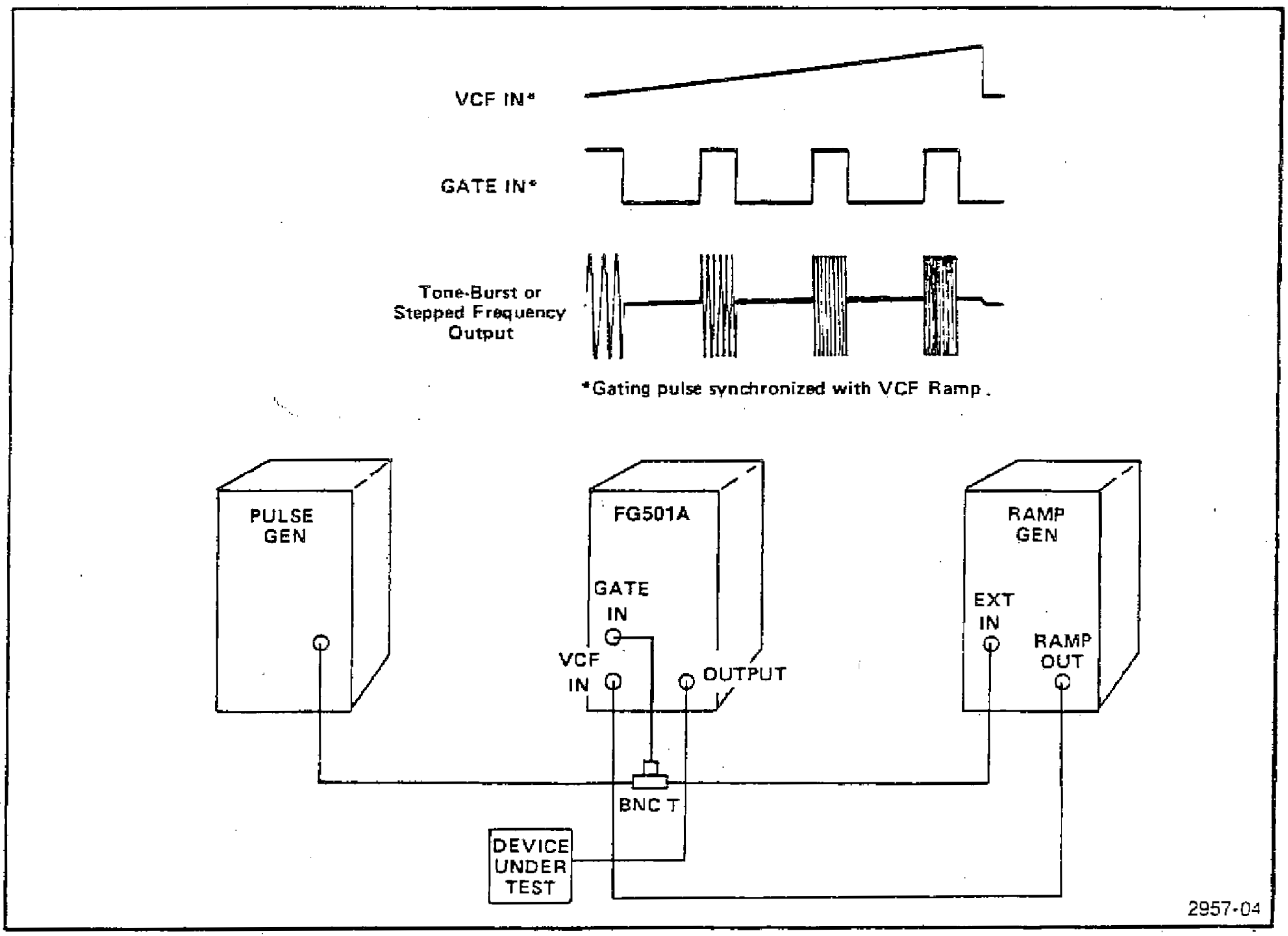


Fig. 2-12. Tone-burst generation or stepped frequency multiplication.

THEORY OF OPERATION

INTRODUCTION

This section of the manual contains a description of the electrical circuits in the FG 501A. Refer to the block diagram and schematic diagrams on the fold out pages in the back of the manual to aid in understanding this description. Diamond enclosed numbers appearing throughout this section refer to the schematic diagram on which the circuit being discussed is located.

LOOP ⟨1⟩

FREQUENCY CONTROL AND SUMMING AMPLIFIER

The voltage developed across the frequency control divider string, R1429, R1321, R500 and R510, is applied to pin 5 of operational amplifier U1540B. This voltage is buffered by the amplifier and a current is developed through R1551. This current is applied to pin 2 of summing amplifier U1540A where it is summed with any currents developed by a voltage applied to the VCF inputs. The VCF inputs are J510 (front panel) through R1553, and pin 21B (rear interface) through R1103. These summed currents are buffered by Q1445 and flow through R1543. The voltage developed across R1543 is proportional to the frequency.

CURRENT SOURCES AND SWITCH

The voltage developed across R1543 is buffered by U1440 and Q1541 which form the negative current source for the main loop timing circuitry. This same voltage is also buffered by U1540C and Q1543 which form a current source identical to U1440 and Q1541. The output current from Q1543 flows through Q1527, Q1525, and Q1421, which form a current mirror that inverts this current to provide the positive current source for the main loop timing circuitry. The current through R1521 is the timing capacitor charging current; the current through R1536 is the discharging current. The Top Dial Symmetry Cal, R1421, adjusts the balance between these two currents so they are equal in magnitude.

In the normal mode of operation (fixed symmetry) R520 and R540 are in the emitter circuit of Q1541 and Q1543. In this condition, equal amounts of current will flow in both the positive and negative current sources. When S500, VAR SYMM, is activated, R530 is switched into the current source emitter circuits. As R530 is varied from one end to the other, unequal amounts of current flow through the positive and negative current sources. In this manner the symmetry of the waveform generated by the loop is varied. These currents are switched into the junction of CR1531 and CR1533 where they alternately charge and discharge the timing capacitor, producing a triangle waveform. The current switch is formed by Q1531, CR1531, Q1433 and CR1533.

TIMING CAPACITORS AND CAPACITANCE MULTIPLIER ⟨2⟩

The timing capacitors provide for triangle generation in the five fastest MULTIPLIER ranges. They are switched into and out of the circuit in decade steps from 10^5 (C1631) down to 10^1 (C1741).

For the four lower MULTIPLIER ranges, 10^0 down to 10^{-3}, C1741 is switched into the feedback loop of U1930 forming an integrator. Current from the current switch is applied to operational amplifier U1940. A voltage is developed at the output of this amplifier that is proportional to the applied current times the value of R1941 (1 kΩ). This voltage is applied, across one of four resistors, to the input of U1930. These resistors, R1831, R1841, R1842, and R1843, are switched into and out of the circuit in decade steps with the MULTIPLIER switch S1731. This arrangement provides very large values of effective capacitance. The output of U1930 is now the triangle that is applied to the buffer stage.

TRIANGLE BUFFER ⟨1⟩

The voltage developed by the timing capacitor or multiplier (U1930) is applied to the triangle buffer. Q1725 and Q1723 form the differential input stage of this circuit. Q1821 serves as a constant current source for the input differential pair. Q1721 and Q1712 complete the feedback for the amplifier such that the voltage at the emitter of Q1712 is equal to the voltage at the Gate of Q1725.

Loop delay compensation is provided by a network comprised of R1712, R1812, C1712, and C1714. The buffered timing capacitor voltage is applied through this network to the level comparators.

LEVEL COMPARATORS

The level comparators detect upper and lower threshold levels. U1700A is the upper level detector and U1700B the lower. The reference level for these comparators is supplied by U1400B and C. As the threshold levels are detected, the respective comparator triggers U1600B.

REFERENCE VOLTAGES

The reference voltage supplies are composed of U1400B (−) and U1400C (+) and associated components. The upper (positive) level threshold voltage is established by adjusting R1412. This resistor is in a voltage divider string from zener diode VR1413. The voltage developed across R1412 is buffered by U1400C and set to approximately +400 mV at the output. This voltage is applied to pin 5 of U1700A as the upper threshold level reference. This same voltage is also applied to pin 9 of inverter U1400B. R1511 is used to adjust the gain of this stage so that the output is nominally −400 mV. This voltage is applied to pin 13 of U1700B as the lower threshold level reference.

LOOP LOGIC

When a rising voltage at pin 6 of U1700A passes through the threshold level set at pin 5, the output (pin 8) goes low pulling pin 10 of U1600B low. This action sets the flip-flop causing pin 9 (Q) to go high and pin 8 ($\overline{Q}$) to go low. Pin 8 of U1600B is tied back, through R1403, to the junction of CR1431 and VR1532. VR1532 serves as a level shifter to change the TTL output gate to the correct level to drive the current switch (Q1531, CR1531, Q1433, CR1533).

As the voltage at the junction of R1532 and R1534 drops, it pulls the bases of Q1531 and Q1433 low. Q1531 is turned on and Q1433 is turned off. Any current from the positive current source, through R1521, now flows through Q1531 and is shunted to the −15 V supply. With Q1433 turned off, any current flow through the negative current source must come from the positively charged timing capacitor through CR1533.

The falling voltage on the timing capacitor is buffered through the triangle buffer and applied to the level comparators U1700A and U1700B. As the voltage at pin 12 of U1700B falls through the threshold level set at pin 13, the output (pin 1) goes low pulling pin 13 of U1600B low. This action resets the flip-flop causing pin 9 (Q) to now go low and pin 8 ($\overline{Q}$) to go high. Taking this high at pin 8 back to the current switch, Q1531 will be turned off and Q1433 turned on. This allows the timing capacitor to charge in the positive direction.

The action just described generates one entire cycle of a triangle wave.

TRIGGER GENERATOR

The square wave output at pin 8 ($\overline{Q}$) of U1600B also drives the trigger output amplifier. This circuit is composed of emitter follower Q1431 and associated components. Q1440, in conjunction with R1440, serves as output short circuit protection. The output of this circuit (at J2043) is a square wave 180° out of phase with the main loop signal. The output amplitude is greater than +4 V into an open circuit, and at least +2 V into a 50 Ω load.

SQUARE WAVE GENERATOR

The output at pin 9 (Q) of U1600B is a square wave, but 180° out of phase with that at pin 8. This signal is used to drive the square wave generator composed of differential pair Q1801, Q1901, and associated components. The base of Q1901 is held at a constant voltage by divider network R1815 and R1818. R1728 and R1816 form a constant current source for the differential pair. The square wave from U1600B alternately switches this constant current to ground through Q1801 or through R1819 and Q1901. In this manner, a square wave voltage is developed with dc levels sufficient to drive the output amplifier for the square wave function.

PHASE CLAMP THRESHOLD DETECTOR

The output of the triangle buffer, in addition to possibly being fed to the Output Amplifier through S1901B, is connected to the base of Q1711. Q1711 and Q1611 form a differential amplifier. Q1621 and associated components provide a constant current source for the differential pair. This amplifier senses the level of the triangle waveform and compares it to the output voltage of U1400A. The output voltage of U1400A is determined by the setting of the VAR Ø control, R550. The voltage range of R550 is established by reference voltage supplies U1400B (−) and U1400C (+). These are the same reference voltages supplied to the Level Comparators. This arrangement permits comparison of the triangle voltage with the maximum possible positive and negative levels, and all levels between.

When the triangle voltage exceeds the reference voltage set by the VAR Ø control, Q1711 turns off. Any current flowing through Q1621 now flows through Q1611.

CURRENT AMPLIFIER

Current flowing through Q1611 also flows through R1622 and is amplified by Q1521. Temperature compensation for this amplifier is provided by CR1621. Differential pair Q1511 and Q1523 serve as a current switch. With Q1511 turned off, any current amplified by Q1521 passes through Q1523 to the junction of CR1531 and CR1533. When the timing capacitor voltage rises to the threshold level set by the VAR Ø control, R550, it is clamped. Q1523 now draws exactly the amount of current that the positive current source supplies. Because the square wave at pin 5 (Q) of U1600A drives the base of Q1511, the clamping action only happens during the positive edge of the triangle wave. On the negative transition, Q1523 is shut off, and Q1511 is on. In this manner, the timing capacitor voltage can be clamped at any desired positive level.

TRIG/GATE AMP AND SINE SHAPER ③

TRIG/GATE AMP AND LOGIC

The input trigger amplifier consists of an emitter coupled differential pair (Q1320 and Q1322), current amplifier Q1324, and the required logic circuitry to control the operation of the main loop phase clamp. Input circuit protection is provided by R1203, R1204, CR1220 and CR1221. Triggering signals are applied either through front panel connector J520 or interface connections on the rear edge of the Main circuit board.

The differential pair, Q1320-Q1322, responds to the input signal when the voltage rises above (+ SLOPE) the reference voltage at the base of Q1320. This reference voltage is established by divider network R1312 and R1314. The position of S1400D, SLOPE switch, determines whether a positive or negative going input will cause the amplifier Q1324 to conduct. When the threshold level is exceeded and conduction starts, current flow through the circuit causes a voltage to be developed across R1322. This voltage is applied to the base of Q1324. The output at the collector of Q1324 is a TTL compatible waveform to drive the logic circuit, U1310. CR1320 provides temperature compensation for Q1324.

Three modes of operation are selectable with S1400; Triggered, Gated, and Free Running.

In the TRIG mode, S1400A and S1400C are positioned such that the output, pin 6, of U1310B is connected to pin 4, set input, of U1600A. In this mode, a very narrow, negative going voltage pulse is developed by U1310B each time the input waveform passes through the trigger threshold. This low sets U1600A, which deactivates the phase clamp until the triangle generator again starts in the positive direction, and allows the generator to complete one full cycle.

In the GATE mode, S1400A and S1400C are positioned such that the output, pin 3, of U1310A is connected to pin 4, set input, of U1600A. In this mode, a low level is produced whenever the input waveform exceeds the threshold if + SLOPE is selected. The generator free runs as long as this condition exists. As soon as the level at the input connector drops below the threshold, the output voltage of U1310A rises. This high level causes the generator to again stop running when the phase clamp reaches its threshold level at the end of the last complete cycle.

In the FREE RUN mode, S1400A is positioned such that pin 4 of U1600A is held low. The generator now outputs continuous waveforms.

SINE SHAPER

The Sine Shaper is composed of three separate circuit functions: a Transconductance Amplifier, the Shaper Circuitry, and an Output Buffer.

Transconductance Amplifier. Emitter coupled transistors Q1210 and Q1212 along with current source Q1200 form the Transconductance Amplifier. The amplifier converts the triangle voltage at the base of Q1212 to a differential current. This current flows through two sets of diode wired transistors, U1120C, U1120D, U1220C, and U1220D, to the input of the shaper.

Shaper. The active portion of the Shaper is formed by two sets of emitter coupled transistors U1220A, U1220B, U1120A and U1120B. These devices have their inputs wired in series and their outputs cross coupled. U1120E and U1220E are current sources for these devices. The circuit operates by generating a power series approximation to the sine function. The devices in U1120 generate the first order term while those in U1220 generate the second order term in the approximation.

Output Buffer. The Output Buffer is an operational amplifier that converts the differential current from Q1010 and U1020D to a single ended voltage that is applied, through the function switch, to the output amplifier. U1020E is a current source for the emitter coupled differential input pair U1020A and U1020B. Q1012 serves as a current mirror for U1020A and as an active load for U1020B. U1020C is the output emitter follower and R1020 is the feedback resistor.

OUTPUT AMPLIFIER & ATTENUATORS ⟨4⟩

The output amplifier is basically a noninverting operational amplifier whose plus input is the base of Q2101 and minus input is the base of Q2113.

The three basic waveforms are selected by S1901 and applied across R560B and R2335 to the input stage of the amplifier. R560B varies the amplitude of the selected waveform. The feedback network consists of R2011 and R2012, connected from the output to the minus input of the amplifier. C2011 provides high frequency compensation for the feedback, and is used to adjust the squarewave front corner. The input pair, Q2101 and Q2113, amplify the difference between the input waveform and the fedback waveform.

An offset current is also summed with the feedback signal at the base of Q2113 when S510A is closed. This allows R560A to control the dc offset of the output signal.

The output of Q2101 is applied directly to Q2111 which is cascoded with Q2011. The output of Q2113 passes through an inverting amplifier, Q2211, before passing to Q2213 cascoded with Q2311. CR2111 provides temperature compensation for Q2211. The two cascodes form drivers for the amplifier output stage.

The output stage consists of Q2013 and Q2123 in parallel with Q2121 for amplification of positive going signals. Q2321 and Q2323 in parallel with Q2325 form the amplifier for negative going signals. The output is taken at the junction of R2026 and R2228. The 50 Ω output impedance is determined by parallel 100 Ω resistors R2033 and R2131. C2121 in this network provides high frequency compensation for the output impedance. The attenuator circuit is a constant impedance resistive divider network, switch selectable in 20 dB steps.

POWER SUPPLY ⟨5⟩

The FG 501A receives its power from the power module via interface connections on the rear edge of the Main circuit board. The power module supplies plus (+) and minus (−) 33.5 Vdc (unregulated) from which the following regulated voltages are generated.

+20 V SUPPLY

The +33.5 V from the power module is filtered and applied to voltage regulator U1210 (pins 11 and 12). This regulator contains its own reference, operational amplifier, and current limiting elements. The output of the regulator is applied to Q1231 which serves as a driver the the series pass transistor located in the power module. The +20 V output is applied across voltage divider R1201, R1301, and R1315. The output level of the supply is set by R1301 (+15 V Adj) which compares the supply output to the internal reference level of the regulator. This supply is current limited through the action of R1121 and the current limiting element in the regulator. When excessive amounts of current are drawn from the supply, the voltage developed across R1121 turns on the current limiting element in the regulator (U1210). This action reduces the base drive, through Q1231, to the series pass transistor causing the supply to reduce output. This supply is the reference for other supplies in the FG 501A.

+15 V SUPPLY

The +15 V supply consists of U1230D and Q1221. U1230D serves as an error amplifier which compares the +15 V output of the supply to a +15 V reference developed by divider network R1231, R1232 and R1233 from the +20 V supply. Since this supply is sourced from the +20 V, it is inherently current limited by the +20 V supply.

+5 V SUPPLY

The +5 V supply consists of U1230C and Q1331. U1230C serves as an error amplifier which compares the +5 V output to a +5 V reference developed by divider network R1231, R1232 and R1233 from the +20 V supply. Since this supply is sourced from the +15 V and referenced to the +20 V supply, it is inherently current limited under the same conditions that limit those supplies.

−20 V SUPPLY

The −20 V supply is derived from −33.5 V supplied by the power module. The output of operational amplifier U1230A is applied, through Q1245, to the base of Q1241, which serves as a driver for the series pass transistor located in the power module. This supply is also referenced to the +20 V. The supply is current limited through the action of R1141 and Q1243. When excessive amounts of current are drawn through R1141, a voltage sufficient to turn Q1243 on develops across R1141. This action reduces the base drive to the series pass transistor causing the supply to reduce output.

−15 V SUPPLY

The −15 V supply consists of operational amplifier (U1230B) and a series pass feedback regulator (Q1345). The output of the supply is fed back through divider network R1247, R1341, and R1245. The output level is adjusted by R1341. Because this supply is sourced from the −20 V supply, it is current limited by the −20 V supply.

CALIBRATION

PERFORMANCE CHECK

INTRODUCTION

This procedure checks the Electrical Performance Requirements as listed in the Specification section in this manual. Perform the internal adjustment procedure if the instrument fails to meet these checks. If recalibration does not correct the discrepancy, circuit troubleshooting is indicated. Also, use this procedure to determine acceptability of performance in an incoming inspection facility. For convenience, many steps in this procedure check the performance of this instrument at only one value in the specified performance range. Any value within the specified range, within appropriate limits, may be substituted.

TEST EQUIPMENT REQUIRED

The test equipment, or equivalent, listed in Table 4-1 is suggested to perform the performance check and the adjustment procedure.

Table 4-1

TEST EQUIPMENT REQUIRED

Item	Description	Minimum Specifications	Application		Example
			Perf Check	Adj Proc	
1	Power Module	Five compartments or more.	X	X	TEKTRONIX TM 515 or TM 506
2	Oscilloscope System	Minimum Vertical deflection Sweep Rate .5 μs.	X	X	TEKTRONIX 7704A/ 7A16A/7B50
3	Differential Comparator Amplifier	Minimum Vertical deflection factor .1 V/div	X	X	TEKTRONIX 7A13
4	Sampling System			X	TEKTRONIX 7704A/7S11/ 7T11/S-1
5	Spectrum Analyzer		X		TEKTRONIX 7L12
6	Distortion Analyzer	Frequency range from 20 Hz to at least 300 kHz. Distortion resolution <0.25%	X	X	TEKTRONIX AA 501
7	Frequency Counter	Frequency range 0.002 Hz to above 2 MHz. Accuracy within one part in 10^4 ±1 count.	X	X	TEKTRONIX DC 504
8	Digital Multimeter	Range to ±30 V 5 1/2 digits Accuracy 0.1%	X	X	TEKTRONIX DM 501
9	Pulse Generator	0 to 2 V square wave output into 50 Ω load. Period 2 μs; Duration .1 μs	X		TEKTRONIX PG 501
10	Power Supply	0 to 10 V range Accuracy ±10%	X		TEKTRONIX PS 501-1

Table 4-1 (cont)

Item	Description	Minimun Specifications	Application		Example
			Perf Check	Adj Proc	
11	Flexible Extender Cable	Compatible with TM 500-Series		X	Tektronix Part No. 067-0645-02
12	Meter Lead	Black	X	X	Tektronix Part No. 012-0462-01
13	Meter Lead	Red	X	X	Tektronix Part No. 012-0462-00
14	Oscilloscope Probe	X10 10 MΩ	X	X	Tektronix Part No. 010-6053-13
15	Coaxial Cable	50 Ω BNC Connectors	X	X	Tektronix Part No. 012-0057-01
16	Termination	50 Ω BNC Connectors	X	X	Tektronix Part No. 011-0049-01
17	X10 Attenuator	50 Ω (20 dB) BNC		X	Tektronix Part No. 011-0059-02
18	X5 Attenuator	50 Ω (14 dB) BNC		X	Tektronix Part No. 011-0060-02
19	Adapter	BNC Female to Dual Banana	X	X	Tektornix Part No. 103-0090-00
20	AC Calibrator	.1% overall accuracy	X		Fluke 5101B

1. Check Frequency Range

a. Connect the OUTPUT connector of the FG 501 to the counter input.

b. Press the FREE RUN and 0 dB pushbuttons.

c. Press either the ∿, ⊓⊔ or ∼ pushbuttons.

d. Make certain the VAR SYMM and OFFSET controls are off.

e. Set the FREQUENCY Hz dial to 20 and the MULTIPLIER control to the 10^5 position.

f. Adjust the AMPLITUDE control for a stable counter display.

g. CHECK—that the counter reads ≥2 MHz.

h. Activate the VAR SYMM control.

i. Adjust the VAR SYMM control for a 50% duty cycle pulse waveform.

j. CHECK—that the counter reads from 180 kHz to 220 kHz.

k. Change the MULTPLIER to 10^{-3}

l. CHECK—for an output frequency of between 0.0019 Hz and 0.0021 Hz.

m. Disable the VAR SYMM control.

n. Change the FREQUENCY Hz dial to 2.

o. CHECK—that the FREQUENCY Hz dial can be adjusted to obtain 0.0002 Hz.

p. Disconnect the counter for the next step.

Tektronix® COMMITTED TO EXCELLENCE

MANUAL CHANGE INFORMATION

Date: 7/14/87 Change Reference: C4/0787

Product: FG 501A Manual Part No.: 070-2957-00

DESCRIPTION Product Group 75

Effective all serial numbers: please replace Step 5 on page 4-3 with the following text:

5. Check Amplitude Flatness

a. Press the FREE RUN, 0dB and ∿ pushbuttons.

b. Make certain the OFFSET is off.

c. Set the FREQUENCY Hz dial to 10, MULTIPLIER to 10^3, and AMPLITUDE control fully clockwise.

d. Connect the OUTPUT connector through a 50 Ω cable and 50 Ω termination to the (+) input of the differential oscilloscope plug-in.

e. Adjust vertical amplifier as follows:

(+) INPUT	DC
(−) INPUT	V_c
VOLT/DIV	.5V
POSITION	Midrange

f. Adjust vertical amplifier COMPARISON VOLTAGE until the positive peaks of the waveform are on the graticule center line.

g. Change the output to any frequency from 20 Hz to 20 kHz.

h. Check that the positive peaks of the waveform stay within 1.7 minor divisions of the graticule center line.

i. Change the output to any frequency from 20 kHz to 1 MHz.

j. Check that the positive peaks of the waveform stay within +1.7/−1.6 major divisions of the graticule center line.

k. Change the output to any frequency from 1 MHz to 2 MHz.

l. Check that the positive peaks of the waveform stay within +3.6/−3.2 major divisions of the graticule center line.

m. Set the FREQUENCY Hz dial to 10, MULTIPLIER to 10^3, and ⋀⋁ button in.

n. Adjust vertical amplifier COMPARISON VOLTAGE until the positive peaks of the waveform are on the graticule center line.

o. Change the output to any frequency from 20 Hz to 200 kHz.

p. Check that the positive peaks of the waveform stay within +1.7/−1.6 major divisions of the graticule center line.

q. Set the FREQUENCY Hz dial to 10, MULTIPLIER to 10^3, and the VOLTS/DIV of the vertical amplifier to 1 volt.

r. Adjust vertical amplifier COMPARISON VOLTAGE until the positive peaks of the waveform are on the graticule center line.

s. Change the output to any frequency from 200 kHz to 2 MHz.

t. Check that the positive peaks of the waveform stay within +3.8/−3.0 major divisions of the graticule center line.

u. Set the FREQUENCY Hz dial to 10, MULTIPLIER to 10^3, and ⊓⊔ button in.

v. Set the VOLTS/DIV of the vertical amplifier to 2V and the (−) INPUT to GND.

w. Adjust the AMPLITUDE control for a display of exactly 6.0 major divisions peak to peak.

x. Change the output to any frequency from 20 Hz to 2 MHz.

y. Check that the peak to peak voltage on the scope remains between 5.7 and 6.3 major divisions.

z. Disconnect the oscilloscope for the next step.

On page 4-2: Delete item 20 (AC Calibrator) from Table 4-1.

2. Check Variable Symmetry Duty Cycle

a. Press the FREE RUN, 0 dB and ⊓⊔ pushbuttons.

b. Set the MULTIPLIER to 10^3 and the FREQUENCY dial to 10.

c. Release the VAR SYMM pushbutton.

d. Connect the OUTPUT connector through a 50 Ω coaxial cable to the oscilloscope vertical input.

e. Adjust the AMPLITUDE and oscilloscope controls to display a waveform that occupies exactly 10 major divisions for one cycle.

f. Rotate the VAR SYMM control from fully cw to fully ccw.

g. Readjust the oscilloscope controls as needed at each extreme to display one cycle for 10 major divisions.

h. CHECK—that the oscilloscope varies each waveform half cycle from ⩽0.5 major divisions to ⩾9.5 major divisions.

i. Leave these connections for the next step.

3. Check Output Amplitude

a. Using the same setup as in the previous step, turn the AMPLITUDE control fully cw.

b. CHECK—that the waveform on the oscilloscope display is ⩾30 V peak to peak.

c. Remove the coaxial cable from the oscilloscope vertical input and connect a 50 Ω termination in series with the cable.

d. CHECK—that the oscilloscope display is ⩾15 V peak to peak.

e. Disconnect the 50 Ω cable and remove the 50 Ω termination from the oscilloscope for the next step.

4. Check Offset Range

a. Press the TRIG 0 dB, and ⊢⊣ pushbuttons.

b. Make certain the VAR SYMM pushbutton is in.

c. Connect a dmm set to read ±15 V to the output connector.

d. Adjust the VAR Ø control for a 0 V reading on the dmm.

e. Pull and turn the OFFSET control fully cw to fully ccw.

f. CHECK—that the dmm reads ⩾±13 V at the appropriate stops for the OFFSET control.

g. Remove the coaxial cable from the dmm and insert a 50 Ω termination.

h. CHECK—that the dmm reads at least ±6.5 V at the appropriate stops of the OFFSET control.

i. Remove the connections from the dmm for the next step.

5. Check Amplitude Flatness

a. Press the FREE RUN, 0 dB and ∿ pushbuttons.

b. Make certain the OFFSET is off.

c. Set the START dial to 10 and the MULTIPLIER to 10^3.

d. Set the AC Calibrator amplitude to 5.000 V rms. Set the AC Calibrator frequency to 10 kHz.

e. Connect the AC Calibrator through a 50 Ω bnc cable and 50 Ω bnc termination to the DMM input and note the reading.

f. Disconnect the AC Calibrator and connect the FG501A OUTPUT to the DMM input through the 50 Ω cable and 50 Ω bnc termination.

g. Adjust the FG501A AMPLITUDE to match the reading noted in step e.

h. Set the AC Calibrator frequency to 20 Hz. Set the START dial to 2 and the MULTIPLIER to 10.

i. Disconnect the FG501A and reconnect the AC Calibrator to the DMM through the 50 Ω cable and termination. Note the DMM reading.

j. Disconnect the AC Calibrator and reconnect the FG501A OUTPUT to the DMM input through the 50 Ω cable and termination.

k. CHECK—that the reading is between .9886 and 1.0114 times the reading noted in step i.

l. Set the AC Calibrator frequency to 20 kHz. Set the START dial to 20 and the MULTIPLIER to 10^3. Repeat steps i through k.

m. Set the AC Calibrator and the FG501A to any other frequency between 20 Hz and 20 kHz and repeat steps i through k.

n. Set the FREQUENCY Hz dial to 10 and the MULTIPLIER to 10^3.

o. Connect the OUTPUT connector through a 50 Ω cable and 50 Ω termination to the vertical input of the differential oscilloscope plug-in.

p. Adjust the AMPLITUDE control and the gain of the vertical amplifier for an 8 major division peak to peak display.

q. Increase the vertical amplifier gain by a factor or 10.

r. Adjust the vertical amplifier plug-in offset voltage so that the waveform peaks are on the oscilloscope graticule center line.

s. Change the output to any frequency from 20 kHz to 1 MHz.

t. CHECK—that the display is within 2.37 major divisions from graticule center.

u. Decrease the vertical gain of the oscilloscope by a factor of 10 and adjust the offset voltage to 0.

v. Adjust the output frequency to 10 kHz.

w. Adjust the oscilloscope vertical gain and the AMPLITUDE control for a 6 major division peak to peak display.

x. Change the output to any frequency from 1 MHz to 2 MHz.

y. CHECK—that the peak to peak display amplitude is from 5.36 to 6.73 major divisions.

z. Press the ⊓⊔ pushbutton.

aa. Set the output frequency to 10 kHz.

bb. Adjust the AMPLITUDE control and the vertical comparator oscilloscope plug-in for an 8 major division peak to peak display.

cc. Increase the oscilloscope vertical plug-in gain by a factor of 10.

dd. Adjust the vertical plug-in offset voltage so that the positive peaks of the squarewaves are at graticule center.

ee. Change the output to any frequency from 20 Hz to 2 MHz.

ff. CHECK—that the positive squarewave peaks are within ±2.37 major divisions from graticule center.

gg. Press the ∿ pushbutton.

hh. Change the output frequency to 10 kHz.

ii. Decrease the oscilloscope vertical plug-in gain by a factor of 10.

jj. Adjust the vertical plug-in offset voltage to 0.

kk. Adjust the AMPLITUDE control and the vertical plug-in gain for an 8 major division oscilloscope display of the triangle waveform.

ll. Increase the plug-in gain by a factor of 10.

mm. Adjust the offset voltage so that the positive peak of the triangle waveform is at graticule center.

nn. Change the output to any frequency from 20 Hz to 200 kHz.

oo. CHECK—that the positive peak of the triangle waveform is 2.37 major divisions or less from the graticule center.

pp. Decrease the vertical amplifier gain by a factor of 10.

qq. Remove the comparison voltage from the vertical plug-in.

rr. Adjust the AMPLTITUDE control and the vertical plug-in gain for a peak to peak triangle waveform display of 6 major divisions.

ss. Change the output to any frequency from 200 kHz to 2 MHz.

tt. CHECK—that the peak to peak display reads from 4.4 major divisions to 7.6 major divisions in amplitude.

uu. Disconnect the oscilloscope for the next step.

6. Check Sinewave Distortion

a. Press the FREE RUN, 0 dB, and ∿ pushbuttons. The VAR SYMM, and OFFSET controls must be off (in).

b. Connect the OUTPUT connector through a 50 Ω coaxial cable and 50 Ω termination to the distortion analyzer.

c. Set the distortion analyzer to measure total harmonic distortion plus noise with average response.

d. Make certain the function generator is in an ambient temperature from 20° C to 30° C.

e. Select any frequency from 20 Hz to 20 kHz with the FREQUENCY Hz and MULTIPLIER controls. The FREQUENCY Hz control must be on the calibrated portion of the dial and the MULTIPLIER control must be on the 10^3 range or below.

f. Adjust the AMPLITUDE control for a 15 V peak to peak signal at the input of the distortion analyzer.

g. CHECK—that the distortion is ≤0.25%.

h. Select any frequency from 20 kHz to 100 kHz. The FREQUENCY Hz control must be on the calibrated portion of the dial.

i. CHECK—that the distortion is ≤0.5%.

j. Disconnect the distortion analyzer and the 50 Ω termination from the coaxial cable.

k. Connect the coaxial cable to the input of the spectrum analyzer.

l. Set the FREQUENCY Hz dial at 10 and the MULTIPLIER at 10^4.

m. Adjust the AMPLITUDE control and the spectrum analyzer controls so that amplitudes 30 dB or greater below the fundamental amplitude are easily viewed on the spectrum analyzer.

n. Rotate the FREQUENCY Hz dial to 20, change the MULTIPLER to 10^5, and rotate the FREQUENCY Hz dial from 20 to 2

o. CHECK—that all harmonics from 100 kHz to 2 MHz are at least 30 dB below the fundamental amplitude.

p. Remove the connections to the spectrum analyzer for the next step.

7. Check Squarewave and Pulse Output

a. Press the FREE RUN, 0 dB and ⊓⊔ pushbuttons. All other pushbuttons out.

b. Set the FREQUENCY Hz dial and the MULTIPLIER control for any calibrated frequency. (For ease, the FREQUENCY Hz dial at 20 and the MULTIPLIER at 10^5 are recommended.)

c. Turn the AMPLITUDE control fully cw.

d. Connect the OUTPUT connector through a 50 Ω coaxial cable and the necessary attenuators to obtain a 5 division display to the 50 Ω vertical input of the sampling oscilloscope.

e. Connect the TRIG OUTPUT connector through a 50 Ω coaxial cable and the necessary attenuators to the external trigger input on the sampling oscilloscope.

f. Obtain a stable rise and fall time display on the oscilloscope.

g. CHECK—that the rise time and fall time is ≤25 ns from the 10% to the 90% amplitude points.

h. CHECK—that the peak to peak amplitude of the front corner ringing does not exceed 3% of the total squarewave amplitude. (If the squarewave amplitude is 8 major divisions, maximum aberrations allowed are 0.24 major divisions.)

i. Release the VAR SYMM pushbutton.

j. Adjust the VAR SYMM control for a pulse waveform.

k. Repeat steps f and g.

l. Remove all connections for the next step.

8. Check VCF Input

a. Press the FREE RUN, 0 dB and ∿ pushbuttons. The VAR SYMM and OFFSET pushbuttons should be in. Set the FREQUENCY Hz dial to 20 and the MULTPLIER to 10^5.

b. Connect the OUTPUT connector through a 50 Ω coaxial cable to the input of the frequency counter.

c. Obtain a stable counter display.

d. Apply −10 Vdc to the VCF INPUT connector.

e. CHECK—that the frequency decreases by a factor of ⩾1000.

Remove all connections for the next step.

9. Check External Trigger/Gate Input

a. Press the TRIG, 0 dB, and ∿ pushbuttons.

b. Connect the OUTPUT connector to the vertical input of the oscilloscope.

c. Connect the pulse generator through a 50 Ω coaxial cable and 50 Ω termination to the TRIG/GATE IN connector.

d. Set the pulse generator for a 0 to 1.2 V positive going 50% duty cycle pulse at 1/2 the frequency of the FG 501A.

e. CHECK—for one cycle of a sine waveform for each trigger pulse.

f. Press the GATE pushbutton.

g. CHECK—for an output waveform that lasts for the duration of the gating waveform.

h. Remove all connections for the next step.

10. Check Trigger Output

a. Press the FREE RUN pushbutton.

b. Connect the TRIG OUTPUT connector through a 50 Ω coaxial cable to the vertical input of the oscilloscope.

c. CHECK—for a ⩾+4 V waveform on the oscilloscope display. (The voltage varies from about +0.7 V to over +4.0 V, TTL logic levels).

d. Insert a 50 Ω termination from the coaxial cable to the oscilloscope vertical input.

e. CHECK—for a ⩾+2 V waveform on the oscilloscope display.

f. Remove all connections for the next step.

11. Check Variable Phase Range

a. Press the FREE RUN, 0 dB, and ∿ pushbuttons.

b. Connect the OUTPUT connector to the vertical input of the oscilloscope. Set the oscilloscope for automatic triggering.

c. Obtain a sine waveform on the oscilloscope centered around 0 V. Determine the peak-to-peak amplitude of the waveform.

d. Press the TRIG pushbutton.

e. Rotate the VAR Ø from stop to stop and observe the position of the free running trace on the oscillosocope display.

f. CHECK—that the straight line can be positioned at the peak amplitudes of the sine waveform.

g. Remove all connections for the next step.

12. Check Attenuator Accuracy

a. Press the FREE RUN, 0 dB and ∿ pushbuttons.

b. Set the FREQUENCY Hz dial to 20.

c. Set the MULTIPLIER to the 10^3 position.

d. Set the AMPLITUDE control fully cw.

e. Connect the OUTPUT connector thorugh a 50 Ω coaxial cable and 50 Ω termination to the input of the dB ratio meter (AA 501).

f. Set the AA 501 for automatic level ranging.

g. Push the 0 dB REF button on the AA 501.

h. Push the −20 dB pushbutton.

i. CHECK—that the ratio meter reads from −19 dB to −21 dB.

j. Push the −40 dB pushbutton.

k. CHECK—that the display reads from −39 dB to −41 dB.

l. Push the −60 dB pushbutton.

m. CHECK—that the display reads from −59 dB to −61 dB.

n. Remove all connections for the next step.

12A. Alternate Procedure for Checking Attenuator Accuracy

a. Press the FREE RUN, 0 dB, and ∿ pushbuttons.

b. Set the FREQUENCY Hz dial to 20.

c. Set the MULTIPLIER to 10^3 position. Connect the output through a coaxial cable to the oscilloscope vertical input.

d. Adjust the AMPLITUDE control for exactly a 30 V peak to peak sinewave.

e. Push the −20 dB pushbutton.

f. CHECK—for a waveform amplitude from 2.67 V to 3.37 V.

g. Press the −40 dB pushbutton.

h. CHECK—for a waveform amplitude from 0.267 V to 0.337 V.

i. Press the −60 dB pushbutton.

j. CHECK—for a waveform amplitude from 0.0267 V to 0.0337 V.

k. Remove all connections for the next step.

13. Check Triangle Time Symmetry

a. Press the FREE RUN pushbutton.

b. Set the FREQUENCY Hz and MULTIPLIER control for any frequency from 20 Hz to 200 kHz in the calibrated portion of the dial. Connect the counter through a coaxial cable to the TRIG OUTPUT connector.

c. Trigger the counter to read the time of the positive-going half cycle of the trigger waveform (+ slope).

d. Record this reading.

e. Trigger the counter to read the negative-going half cycle of the triggering waveform (− slope).

f. Record this reading.

g. CHECK—that the time difference of both readings is $\leq 1\%$.

h. Set the FREQUENCY Hz and MULTIPLIER controls for a frequency from 200 kHz to 2 MHz in the calibrated portion of the FREQUENCY Hz dial.

i. Repeat steps c through f.

j. CHECK—that the time difference is $\leq 5\%$.

k. Remove all connections.

ADJUSTMENT PROCEDURE

INTRODUCTION

Use this Adjustment Procedure to restore the FG 501A to original performance requirements. This Adjustment Procedure need not be performed unless the instrument fails to meet the Performance Requirements of the Electrical Characteristics listed in the Specification section, or if the Performance Check procedure cannot be completed satisfactorily. If the instrument has undegone repairs, the Adjustment Procedure is recommended.

Satisfactory completion of all adjustment steps in this procedure assures that the instrument will meet the performance requirements.

SERVICES AVAILABLE

Tektronix, Inc. provides complete instrument repair and adjustment at local Field Service Centers and at the Factory Service Center. Contact your local Tektronix Field Office or representative for further information.

RECALIBRATION INTERVAL

Recommended recalibration interval is 2000 hours of operation or six months, whichever occurs first.

TEST EQUIPMENT REQUIRED

The test equipment (or equivalent) listed in Table 4-1 is required for adjustment of the FG 501A. Specifications given for the test equipment are the minimum necessary for accurate adjustment. All test equipment is assumed to be correctly calibrated and operating within specifications.

If other test equipment is used, calibration setup may need to be altered to meet the requirements of the equipment used.

PREPARATION

Access to the internal adjustments is achieved most easily when the FG 501A is connected to the power module with a flexible extender (see equipment list). Removal of the left side cover provides access to all internal adjustments. Refer to the Adjustment Locations in the pullout pages at the rear of the manual.

Make adjustments at an ambient temperature between +20° C and +25° C.

PRELIMINARY SETTINGS

Preset the FG 501A and test equipment controls as follows:

CAUTION

To prevent damage to equipment, be sure the power module and oscilloscope mainframe power is off before inserting or removing plug-in units.

Power Module

LINE SELECTOR	HI

FG 501A

⊓⊔ (pushbutton)	in
FREE RUN (pushbutton)	in
0 dB (pushbutton)	in
FREQUENCY Hz dial	20
VAR SYMM	Mid-range & in
VAR Ø	Mid-range
MULTIPLIER	10^3
VAR (frequency)	cw
OFFSET	Mid-range & in
AMPL	cw

Digital Multimeter (DM 501)

RANGE/FUNCTION	20 DC VOLTS
INPUT	EXT

POWER SUPPLIES

1. Adjust the +15 V ADJ (R1301), ±0.1%

a. Insert the FG 501A and digital multimeter into the power module.

b. Connect the power module power cord to 117 Vac source and turn on the power module.

c. Connect the test leads to the digital multimeter HI and LO INPUTS.

d. Connect the digital multimeter LO test lead to the FG 501A chassis ground. Connect the HI test lead to the FG 501A test point, TP1323 located on the Main board.

e. ADJUST—potentiometer R1301 located on the Main board until the digital multimeter readout indicates between +14.985 and +15.015.

2. Adjust the −15 V ADJ (R1341), ±0.1%

a. Remove the digital multimeter HI test lead from TP1323 and connect to test point, TP1451 (also located on the Main board).

b. ADJUST—potentiometer R1341 located on the Main board until the digital multimeter readout indicates between −14.985 and −15.015.

3. Check the +5 V Supply Accuracy, ±0.5%

a. Remove the digital multimeter HI test lead from TP1451 and connect to test point, TP1331 located on the Main board.

b. The digital multimeter must indicate a readout between +4.975 and +5.025.

4. Check the +20 V Supply Accuracy, ±0.5%

a. Change the digital multimeter RANGE/FUNCTION switch to 200 DC VOLTS.

b. Remove the digital multimeter HI test lead from TP 1331 and connect to test point, TP1321 located on the Main board.

c. The digital multimeter must indicate a readout between +19.90 and +20.10.

5. Check the −20 V Supply Accuracy, ±0.5%

a. Remove the digital multimeter HI test lead from TP1321 and connect to test point, TP1241 located on the Main board.

b. The digital multimeter must indicate a readout between −19.90 and −20.10.

c. Remove all connections.

DIAL ALIGNMENT

Refer to Fig. 4-1 test setup and preliminary control settings with the following exceptions.

7000 Series Oscilloscope

POWER	on
FOCUS, INTENSITY	as desired for a well-defined display
VERTICAL MODE	LEFT
HORIZONTAL MODE	B
B TRIGGER SOURCE	VERT MODE

Vertial Plug-in

VOLTS/DIV	5
VARIABLE	in
BANDWIDTH	FULL
POLARITY	+ (UP)
AC-GND-DC	DC
POSITION	centered display

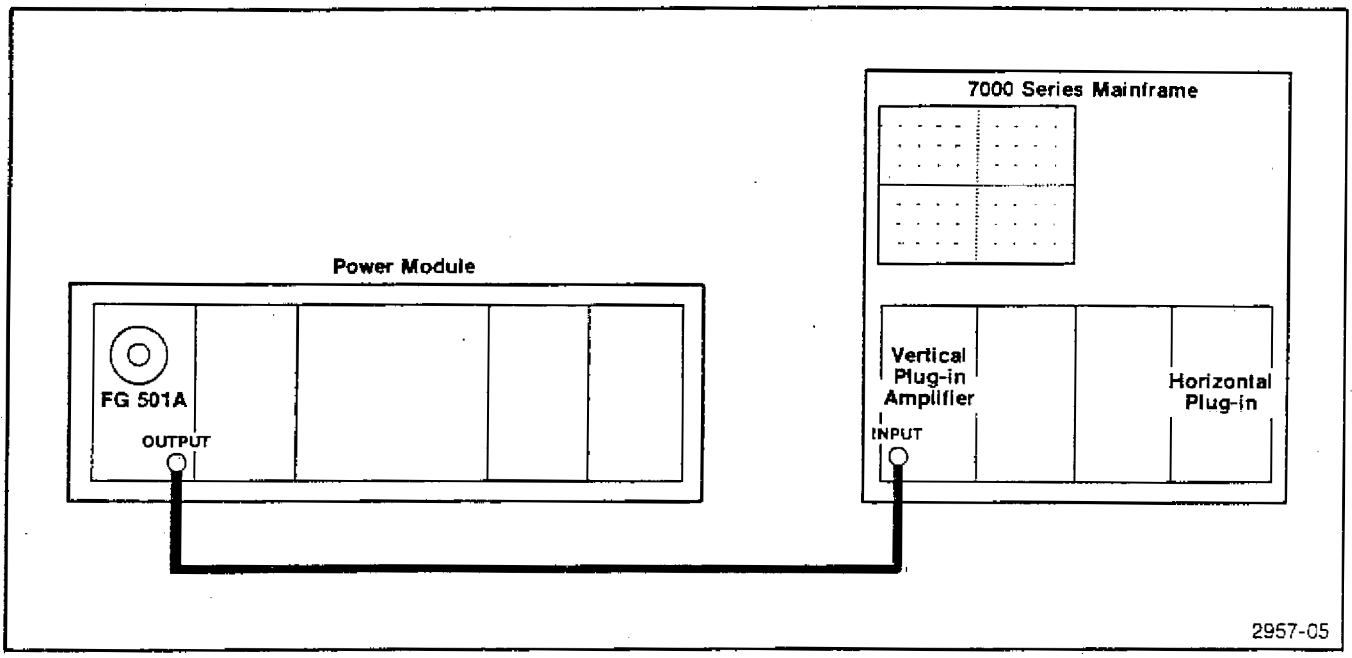


Fig. 4-1. Test setup for DIAL ALIGNMENT and OFFSET adjustment.

Horizontal Plug-in

DISPLAY MODE	TIME BASE
TIME/DIV	50 μs
VARIABLE	in
LEVEL/SLOPE	+
MODE	AUTO
COUPLING	AC
SOURCE	INT
MAGNIFIER	X1

6. Frequency Hz Dial Alignment

a. Connect the coaxial cable from the FG 501A OUTPUT to the vertical plug-in INPUT.

b. Adjust the horizontal plug-in LEVEL control for a stable squarewave display on the crt.

c. Locate the coupler holding the FREQUENCY Hz potentiometer extension shaft and loosen the coupler set screw.

d. ADJUST—the FREQUENCY Hz potentiometer counterclockwise until the displayed waveform just stops moving.

e. While holding the potentiometer (coupler), adjust the FREQUENCY Hz dial to 20 (exact).

f. Tighten the coupler set screw (snug only).

g. Adjust the FREQUENCY Hz dial to 18. Then rotate dial slowly counterclockwise until the display crt waveform just stops moving.

h. Check that the FREQUENCY Hz dial is on 20 (±.5 minor graticule division).

i. Tighten the coupler set screw.

ADJUST OFFSET

Refer to Fig. 4-1 test setup and preliminary control settings with the following exceptions.

FG 501A

AMPLITUDE	ccw
∿ (pushbutton)	in
FREQUENCY Hz	20
MULTIPLIER	10^2

Vertical Plug-in

VOLTS/DIV	2

7. Adjust the OUTPUT OFFSET (R2201) and SINE OFFSET (R1104)

a. The oscilloscope crt display is a triangle.

b. ADJUST—potentiometer R2201 located on the Main board until the displayed waveform is centered on the vertical graticule line.

c. Press the ∿ (pushbutton) in.

d. The oscilloscope crt display is a sinewave.

e. ADJUST—potentiometer R1104 located on the Aux board until the displayed waveform is centered on the vertical graticule line.

ADJUST SINE DISTORTION

8. Adjust the TRIANGLE AMPL ADJ (R1412), TRIANGLE OFFSET (R1511), and TOP DIAL SYMM CAL (R1421)

Refer to Fig. 4-2 check setup and preliminary control settings with the following exceptions.

FG 501A

AMPLITUDE	cw

Audio Analyzer

INPUT LEVEL RANGE	20 V
FUNCTION	THD+N
PERCENT DISTORTION	AUTO
FILTERS	OUT
RESPONSE	AVE

a. Remove the vertical plug-in INPUT connection and re-connect to the audio analyzer using a bnc to banana plug adapter.

b. ADJUST—potentiometers R1412, R1511, and R1421 all located on the Main board for a minimum reading on the audio analyzer. Repeat these adjustments until no further improvement is noted.

9. Adjust the "C" MULT ADJ (R1951)

Refer to Fig. 4-2 test setup and preliminary control settings with the following exceptions.

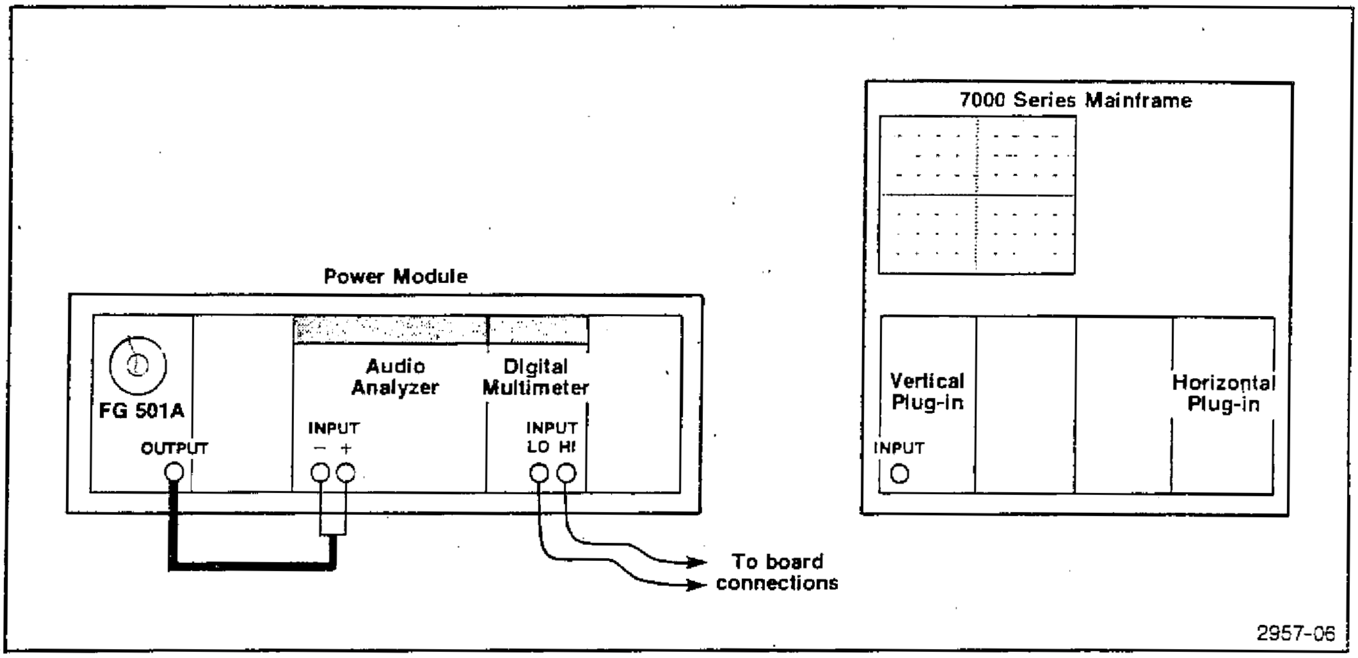


Fig. 4-2. Test setup for SINE DISTORTION adjustment.

Digital Multimeter

RANGE/FUNCTION	2 DC Volts

FG 501A

MULTIPLIER	1

a. Connect the digital multimeter LO INPUT test lead to pin 2 of IC, U1930 located on the Main board.

b. Connect the HI INPUT test lead to pin 2 of IC, U1940 also located on the Main board.

c. ADJUST—potentiometer R1951 located on the Main board for a .0000 digital multimeter readout.

d. Remove digital multimeter test leads.

10. Adjust the BOTTOM DIAL SYMM CAL (R1441)

Refer to Fig. 4-2 test setup.

a. Adjust the FG 501A FREQUENCY Hz dial to 1 and change the MULTIPLIER to 10^2.

b. ADJUST—potentiometer R1441 for a minimum reading on the audio analyzer.

OFFSET ADJUSTS

Refer to Fig. 4-3 test setup and preliminary control settings with the following exceptions:

FG 501A

∿ (pushbutton)	in
MULTIPLIER	10^2
OUTPUT	ccw

Vertical Plug-in

VOLTS Polarity	+
+ INPUT Coupling	GND
− INPUT Coupling	GND
VOLTS/DIV	.1

11. Adjust OUTPUT OFFSET (R2201)

a. Connect a coaxial cable with 50 Ω termination from the FG 501A OUTPUT to the vertical plug-in + INPUT.

b. Adjust the vertical plug-in POSITION control until the trace lines up on the center horizontal graticule line.

c. Change the vertical plug-in + INPUT coupling to DC.

d. Adjust the vertical plug-in COMPARISON VOLTAGE control until the positive peak of the displayed waveform appears as graticule center.

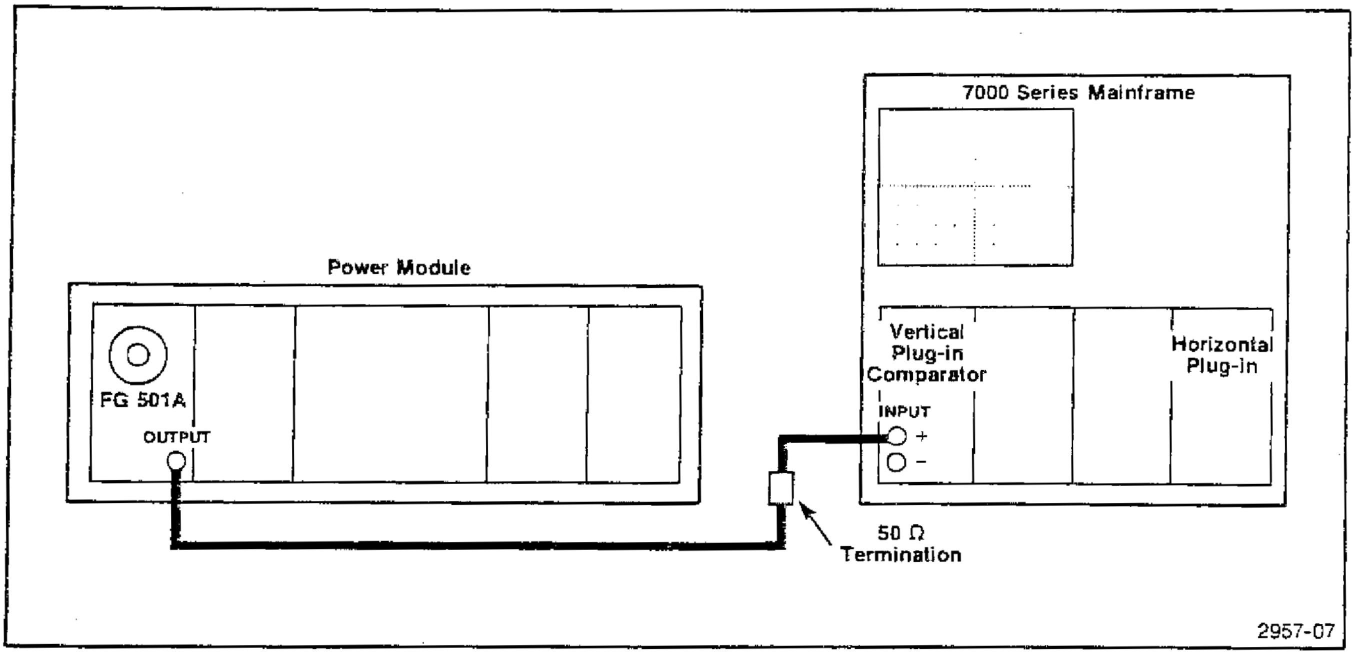


Fig. 4-3. Test setup for OFFSET and SINE/SQUARE AMPLITUDE adjustments.

e. Change the vertical plug-in VOLTS polarity to −.

f. Adjust the vertical plug-in COMPARISON VOLTAGE control until the negative peak of the displayed waveform moves half-way between its present position and the center horizontal graticule line.

g. ADJUST—potentiometer R2201 located on the Main board until the negative peak of the displayed waveform is on the center horizontal graticule line.

12. Adjust the SINE OFFSET (R1104)

a. Change the vertical plug-in VOLTS polarity to + and press the ∿ pushbutton (in).

b. Adjust the vertical plug-in COMPARISON VOLTAGE control until the positive peak of the displayed waveform appears at graticule center.

c. Change the vertical plug-in VOLTS polarity to −

d. Adjust the vertical plug-in COMPARISON VOLTAGE control until the negative peak of the displayed waveform moves half-way between its present position and the center horizontal graticule line.

e. ADJUST—potentiometer R1104 located on the Aux board until the negative peak of the displayed waveform is on the center horizontal graticule line.

SINE/SQUARE AMPLITUDE ADJUSTS

Refer to Fig. 4-3 test setup and the preliminary controls settings with the following exceptions:

FG 501A

∿ (pushbutton)	in
AMPLITUDE	cw

Vertical Plug-in

VOLTS/DIV	.2
+INPUT Coupling	GND
−INPUT Coupling	GND

13. Adjust the SINE AMPL (R1106)

a. Adjust the vertical plug-in POSITION control until the trace lines up on the center horizontal graticule line.

b. Change the vertical plug-in VOLTS polarity to −

c. Change the vertical plug-in + INPUT coupling to DC and the − INPUT coupling to VC.

d. Adjust the vertical plug-in COMPARISON VOLTAGE control until the negative peak of the displayed waveform appears at graticule center.

e. Press the FG 501A ∿ pushbutton (in).

f. ADJUST—potentiometer R1106 located on the Aux board until the negative peak of the displayed waveform is on the center horizontal graticule line.

14. Adjust the SQ WAVE AMPL (R1728)

a. Press the FG 501A ⊓⊔ pushbutton (in).

b. Note the position of the negative level of the displayed squarewave.

c. Press the FG 501A ∿ pushbutton (in).

d. Change the vertical plug-in VOLTS polarity to +.

e. Adjust the vertical plug-in COMPARISON VOLTAGE control until the positive peak of the displayed waveform is on the center horizontal graticule line.

f. Press the FG 501A ⊓⊔ pushbutton (in).

g. ADJUST—potentiometer R1728 located on the Main board until the positive level of the displayed squarewave is off of the center graticule line in the same direction and same amount as the negative level squarewave noted in step 29b.

SQUAREWAVE COMP/RISE AND FALLTIME ADJUSTS

Refer to Fig. 4-4 test setup and the preliminary control settings with the following exceptions.

FG 501A	
FREQUENCY Hz	20
MULTIPLIER	10^5
AMPLITUDE	ccw
Sampling Vertical Plug-in	
mVOLTS/DIV	200
Sampling Horizontal Plug-in	
SWEEP RANGE	5 μs
TIME/DIV	.1 μs

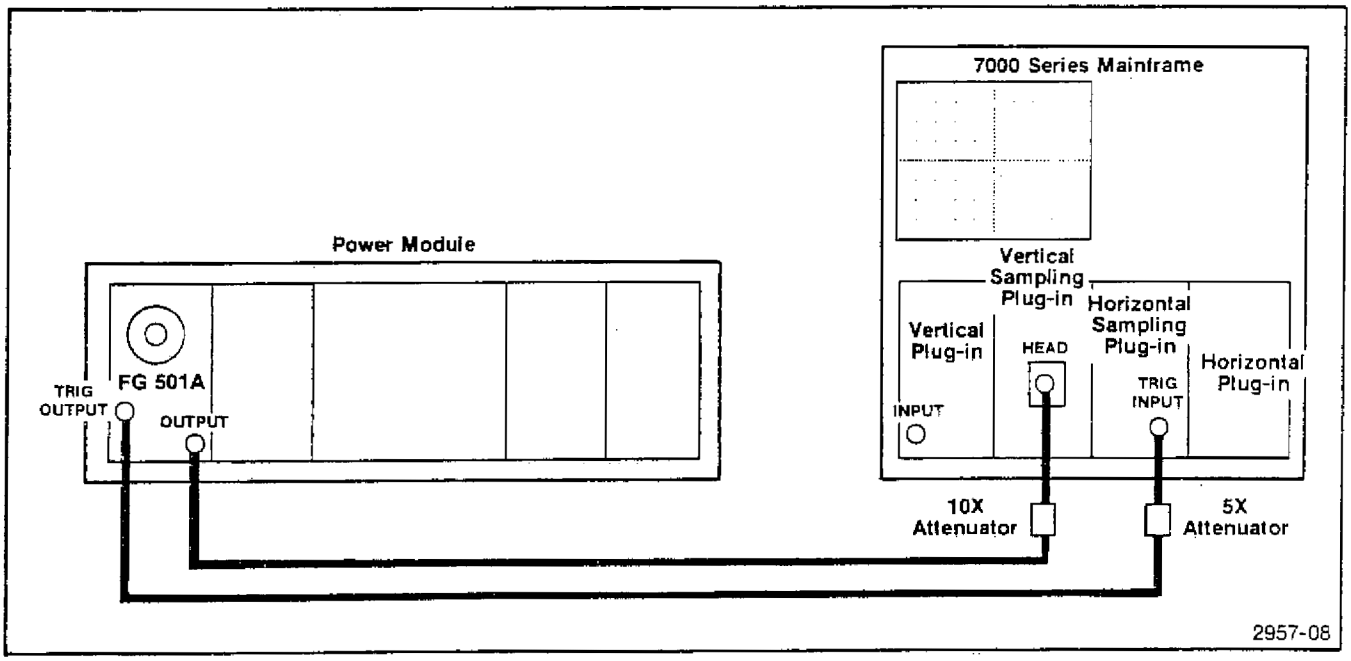


Fig. 4-4. Test setup for SQUAREWAVE COMP/RISE and FALL TIME adjustments.

15. Adjust the SQ WV COMP (C2011)

a. Connect a coaxial cable with a 10X attenuator from the FG 501A OUTPUT to the vertical plug-in sampling head input.

b. Connect a coaxial cable with a 5X attenuator from the FG 501A TRIG OUTPUT to the sampling horizontal plug-in TRIG INPUT.

c. Set the sampling vertical plug-in VARIABLE out and adjust for a displayed waveform amplitude of five major graticule divisions.

d. Change the sampling vertical plug-in mVOLTS/DIV switch to 20.

e. ADJUST—variable capacitor C2011 located on the Main board for a peak-to-peak aberration of 1 major graticule division on the displayed waveform. This aberration will appear at both the top and bottom of the waveform.

DIAL CAL/LOOP DELAY

Refer to Fig. 4-5 test setup and preliminary control settings.

16. Adjust the DIAL CAL (R1321)

a. Connect a 50 Ω coaxial cable and terminator from the FG 501A output to the counter input.

b. ADJUST—potentiometer R1321 located on the main board for a counter display of 20.00.

17. Adjust LOOP DELAY (C1714)

a. Change the FG 501A MULTIPLIER to 10^5 and the digital counter FUNCTION to FREQUENCY/.1 kHz.

b. ADJUST—variable capacitor C1714 located on Main board for a digital counter readout of 2.000.

c. Remove all cables and connections.

This completes the Adjustment Procedure for the FG 501A.

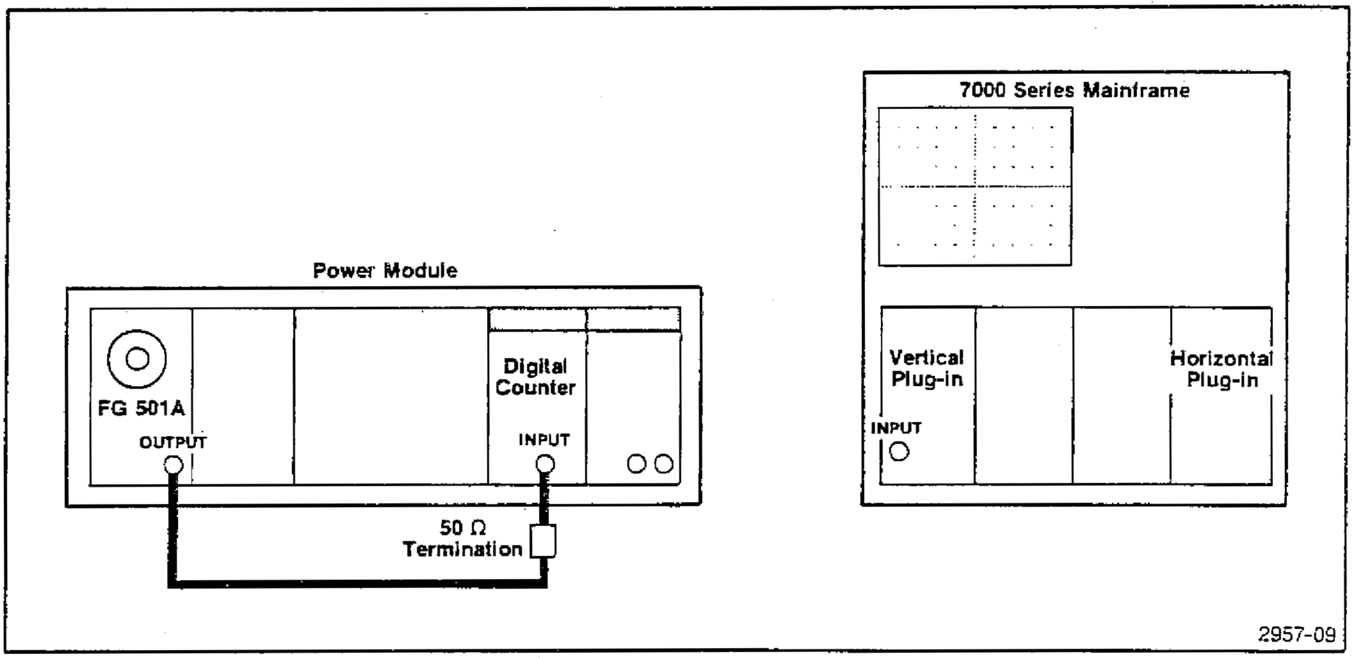


Fig. 4-5. Test setup for DIAL CAL and LOOP DELAY adjustments.

MAINTENANCE

GENERAL MAINTENANCE INFORMATION

STATIC-SENSITIVE COMPONENTS

CAUTION

Static discharge can damage any semiconductor component in this instrument.

This instrument contains electrical components that are susceptible to damage from static discharge. See Table 5-1 for relative susceptibility of various classes of semiconductors. Static voltages of 1 kV to 30 kV are common in unprotected environments.

Observe the following precautions to avoid damage:

1. Minimize handling of static sensitive components.
2. Transport and store static-sensitive components or assemblies in their original containers, on a metal rail, or on conductive foam. Label any package that contains static-sensitive assemblies or components.
3. Discharge the static voltage from your body by wearing a wrist strap while handling these components. Servicing static-sensitive assemblies or components should be performed only at a static-free work station by qualified service personnel.
4. Nothing capable of generating or holding a static charge should be allowed on the work station surface.
5. Keep the component leads shorted together whenever possible.
6. Pick up components by the body, never by the leads.
7. Do not slide the components over any surface.
8. Avoid handling components in areas that have a floor or work surface covering capable of generating a static charge.
9. Use a soldering iron that is connected to earth ground.
10. Use only special antistatic suction type or wick type desoldering tools.

Table 5-1

RELATIVE SUSCEPTIBILITY TO STATIC DISCHARGE DAMAGE

Semiconductor Classes	Relative Susceptibility Levels[a]
MOS or CMOS microcircuits or discretes or linear microcircuits with MOS inputs. (Most Sensitive)	1
ECL	2
Schottky signal diodes	3
Schottky TTL	4
High-frequency bipolar transistors	5
JFETs	6
Linear microcircuits	7
Low-power Schottky TTL	8
TTL (Least Sensitive)	9

[a] Voltage equivalent for levels:

1 = 100 to 500 V	4 = 500 V	7 = 400 to 1000 V (est)
2 = 200 to 500 V	5 = 400 to 600 V	8 = 900 V
3 = 250 V	6 = 600 to 800 V	9 = 1200 V

(Voltage discharged from a 100 pF capacitor through a resistance of 100 ohms.)

CLEANING

This instrument should be cleaned as often as operating conditions require. Loose dust accumulated on the outside of the instrument can be removed with a soft cloth or small brush. Remove dirt that remains with a soft cloth dampened in a mild detergent and water solution. Do not use abrasive cleaners.

CAUTION

To clean the front panel use freon, isopropyl alcohol, or totally denatured ethyl alcohol. Do not use petroleum based cleansing agents. Before using any other type of cleaner, consult your Tektronix Service Center or representative.

The best way to clean the interior is to blow off the accumulated dust with dry, low-velocity air (approximately 5 lb/in^2) or use a soft brush or cloth dampened with a mild detergent and water solution.

Hold the board so the cleaning residue runs away from the connectors. Do not scrape or use an eraser to clean the edge connector contacts. Abrasive cleaning can remove the gold plating.

CAUTION

Circuit boards and components must be dry before applying power.

OBTAINING REPLACEMENT PARTS

Electrical and mechanical parts can be obtained through your local Tektronix Field Office or representative. However, it may be possible to obtain many of the standard electronic components from a local commercial source. Before purchasing or ordering a part from a source other than Tektronix, Inc., check the Replaceable Electrical Parts list for the proper value, rating, tolerance, and description.

NOTE

When selecting replacement parts, remember that the physical size and shape of a component may affect its performance in the instrument.

Some parts are manufactured or selected by Tektronix, Inc., to satisfy particular requirements or are manufactured for Tektronix, Inc., to our specifications. Most of the mechanical parts used in this instrument have been manufactured by Tektronix, Inc. To determine the manufacturer, refer to the Replaceable Parts list and the Cross Reference index, Mfr. Code Number to Manufacturer.

When ordering replacement parts from Tektronix, Inc., include the following information:

1. Instrument type and option number.
2. Instrument serial number.
3. A description of the part (if electrical, include complete circuit number).
4. Tektronix part number.

SOLDERING TECHNIQUES

WARNING

To avoid electric-shock hazard, disconnect the instrument from the power source before soldering.

The reliability and accuracy of this instrument can be maintained only if proper soldering techniques are used when repairing or replacing parts. General soldering techniques which apply to maintenance of any precision electronic equipment should be used when working on this instrument. Use only 60/40 rosin-core electronic grade solder. The choice of soldering iron is determined by the reapir to be made.

When soldering on circuit boards or small wiring, use only a 15 watt, pencil type soldering iron. A higher wattage soldering iron can cause the etched circuit wiring to separate from the board base material and melt the insulation from small wiring. Always keep the soldering iron tip properly tinned to ensure the best heat transfer to the solder joint. Apply only enough heat to remove the component or to make a good solder joint. To protect heat sensitive components, hold the component lead with a pair of long-nose pliers between the component body and the solder joint. Use a solder removing wick to remove excess solder from connections or to clean circuit board pads.

SEMICONDUCTORS

To remove in-line integrated circuits use an extracting tool. This tool is available from Tektronix, Inc.; order Tektronix Part Number 003-0619-00. If an extracting tool is not available, use care to avoid damaging the pins. Pull slowly and evenly on both ends of the integrated circuit. Try to avoid disengaging one end before the other end.

INTERCONNECTING PINS

Several methods of interconnection including multipin and coaxial cable, are used to electrically connect the circuit boards with other boards and components.

COAXIAL CABLES

Replacement of coaxial end lead connectors requires special tools. Damaged cables should be replaced as a unit. For cable part numbers see the Replaceable Mechanical Parts list. Fig. 5-1 shows a coaxial connector assembly.

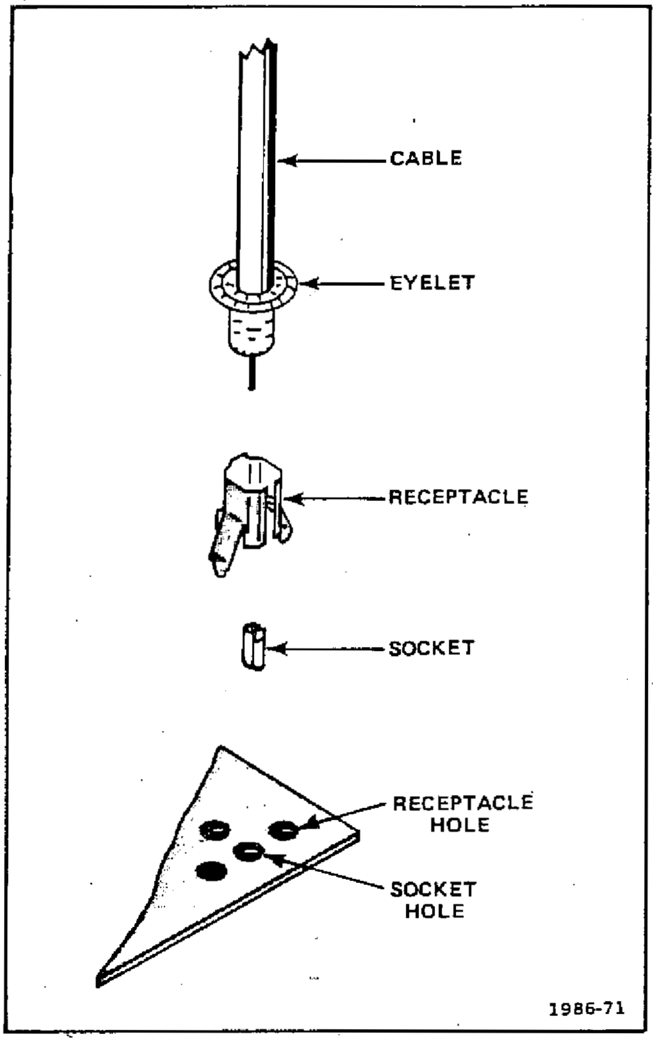


Fig. 5-1. Coaxial end lead connector assembly.

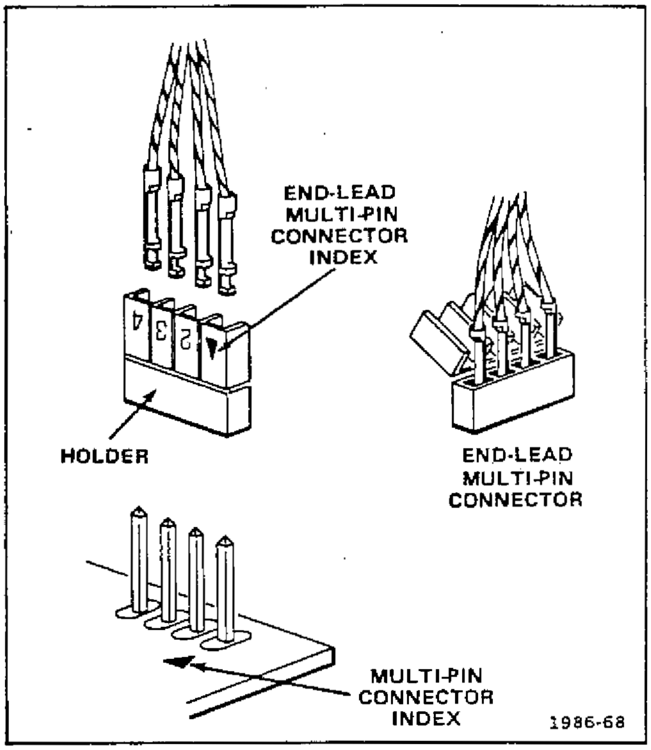


Fig. 5-2. Orientation and disassembly of multipin connectors.

MULTIPIN CONNECTORS

The pin connectors used to connect the wires to the interconnecting pins are clamped to the ends of the wires. To replace damaged multipin connectors, remove the old pin connector from the holder. Do this by inserting a scribe between the connector and the holder and prying the connector from the holder. Clamp the replacement connector to the wire. Reinstall the connector in the holder.

If the individaul end lead pin connectors are removed from the plastic holder, note the order of the individual wires for correct replacement in the holder. For proper replacement see Fig. 5-2.

CAM SWITCHES

Use care when cleaning or repairing cam switches. Shaft alignment and spring tension of the contacts must be carefully maintained for proper operation of the switch. For assistance, contact your local Tektronix Field Office or representative.

NOTE

A cam-type switch repair kit including necessary tools, instructions, and replacement contacts is available from Tektronix, Inc. Order Tektronix Part No. 040-0541-00.

The cam switches consist of rotating cam drums which are turned by front-panel knobs, and sets of spring-leaf contacts mounted on adjacent circuit boards. The contacts are actuated by lobes on the cams. These switches can be disassembled for inspection, cleaning, repair, or replacement as follows:

1. Pull the metal cover off the switch. The switch is now open for inspection or cleaning.

2. To completely remove a switch from the circuit board, first remove any knobs or shaft extensions. Loosen the coupling at the potentiometer at the rear of the switch, and pull the long shaft out of the switch assembly.

3. Remove the screws (from the opposite side of the circuit board) that hold the cam drum to the board.

4. To remove the cam drum from the front support block, remove the retaining ring from the shaft on the front of the switch and slide the cam drum out of the support block. Be careful not to lose the small detent roller.

5. To replace defective switch contacts, follow the instructions given in the switch repair kit.

6. To reinstall the switch assembly, reverse the above procedure.

PUSHBUTTON SWITCHES

See Fig. 5-3 for pushbutton switch disassembly instructions.

FRONT PANEL LATCH REMOVAL

To disassemble the latch, pry up on the pull tab bar attached to the latch assembly. The latch components can now be removed from the instrument.

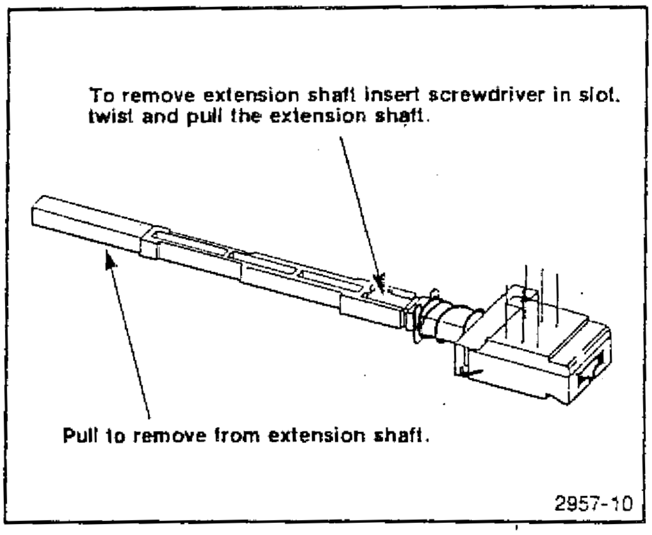


Fig. 5-3. Extension shaft and pushbutton removal.

REAR INTERFACE INFORMATION

FUNCTIONS AVAILABLE AT REAR CONNECTOR

A slot exists between pins 23 and 24 on the rear connector. Insert a barrier in the corresponding position of the power module jack to prevent noncompatible plug-ins from being using in that compartment. Consult the power module manual for further information. Signals for other specialized connections may be made to the rear interface connectors as shown in Fig. 5-4. A description of these connections follows.

Output (From 600 Ω) 28A

The output can be obtained at this terminal by connecting a coax cable from J2141 to J1204 on the A10 Main Board assembly. A 560 Ω resistor is in series with J2141.

Output Common 27A

This is the return connection for the output.

Trigger Output (50 Ω) 27B

This terminal is connected via an internal jumper to the front panel trigger output connector. See the adjustment location illustration for the location of this jumper.

Trigger Out Common 28B

This is the return connection for the trigger output.

Trig/Gate In 24B

This terminal is connected to the trigger amplifier through a 1 KΩ resistor. The output signal is 1 V with an impedance of ≤10 KΩ.

Trig/Gate In Common 25B

This is the return connection for the trig/gate in.

ASSIGNMENTS FUNCTION	CONTACTS	CONTACTS	ASSIGNMENTS FUNCTION
Trigger out common	28B	28A	Output (from 600 Ω)
Trigger output (50 Ω)	27B	27A	Output common
	26B	26A	
Trig/gate in common	25B	25A	
Trig/gate in (1 V, ~2 kΩ)	24B	24A	
			Family key
	23B	23A	
Vcf input common	22B	22A	
Vcf in (0 to ±10 V, 10 kΩ)	21B	21A	
	20B	20A	
	19B	19A	
	18B	18A	
	17B	17A	
	16B	16A	
	15B	15A	
	14B	14A	
	13B	13A	
+33.5 V filtered dc	12B	12A	+33.5 V filtered dc
Collector lead PNP series pass	11B	11A	Base lead PNP series pass
	10B	10A	Emitter lead PNP series pass
±33.5 V common	9B	9A	±33.5 V common
−33.5 V filtered dc	8B	8A	−33.5 V filtered dc
Collector lead NPN series pass	7B	7A	Emitter lead NPN series pass
			TM 500 barrier slot
	6B	6A	Base lead NPN series pass
	5B	5A	
	4B	4A	
	3B	3A	
	2B	2A	
	1B	1A	

2957-11

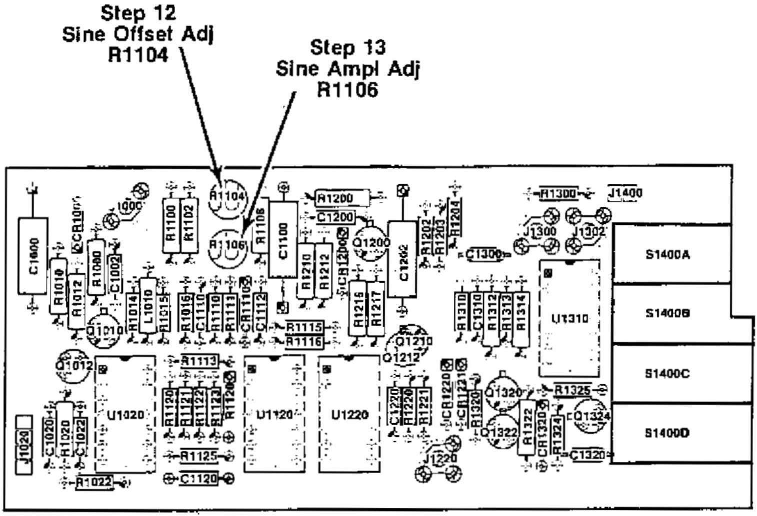
Fig. 5-4. Rear interface connector assignments.

VCF In 21B

This terminal is connected through a 10 KΩ resistor via an internal jumper to the virtual ground summing node of operational amplifier U1540A (pin 2). See the Adjustment Location illustration for the location of this jumper.

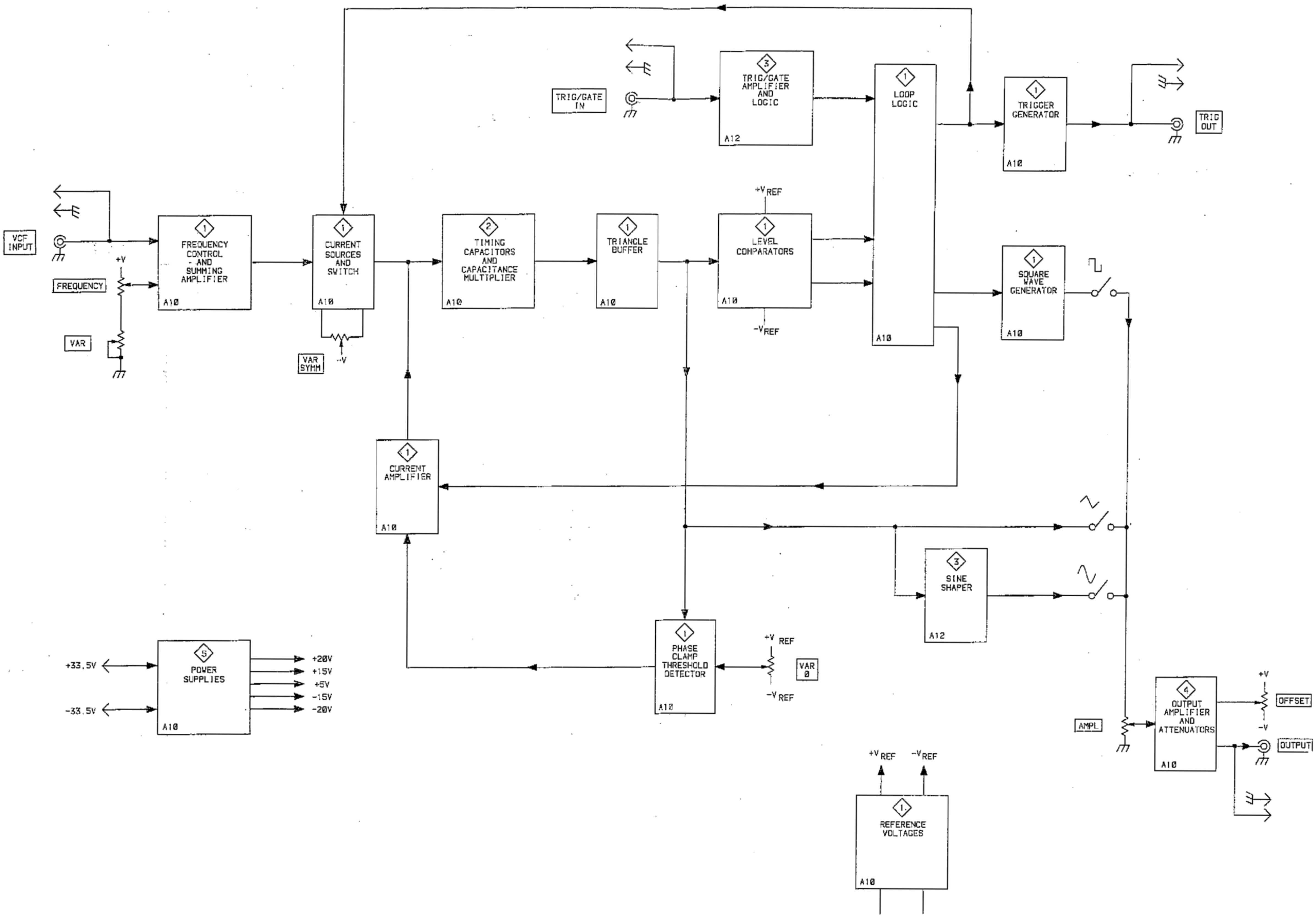
VCF In Common 22B

This connection is the ground return for the VCF In.



2957-12

Fig. 8-1. Auxiliary Board.



FG 5Ø1A

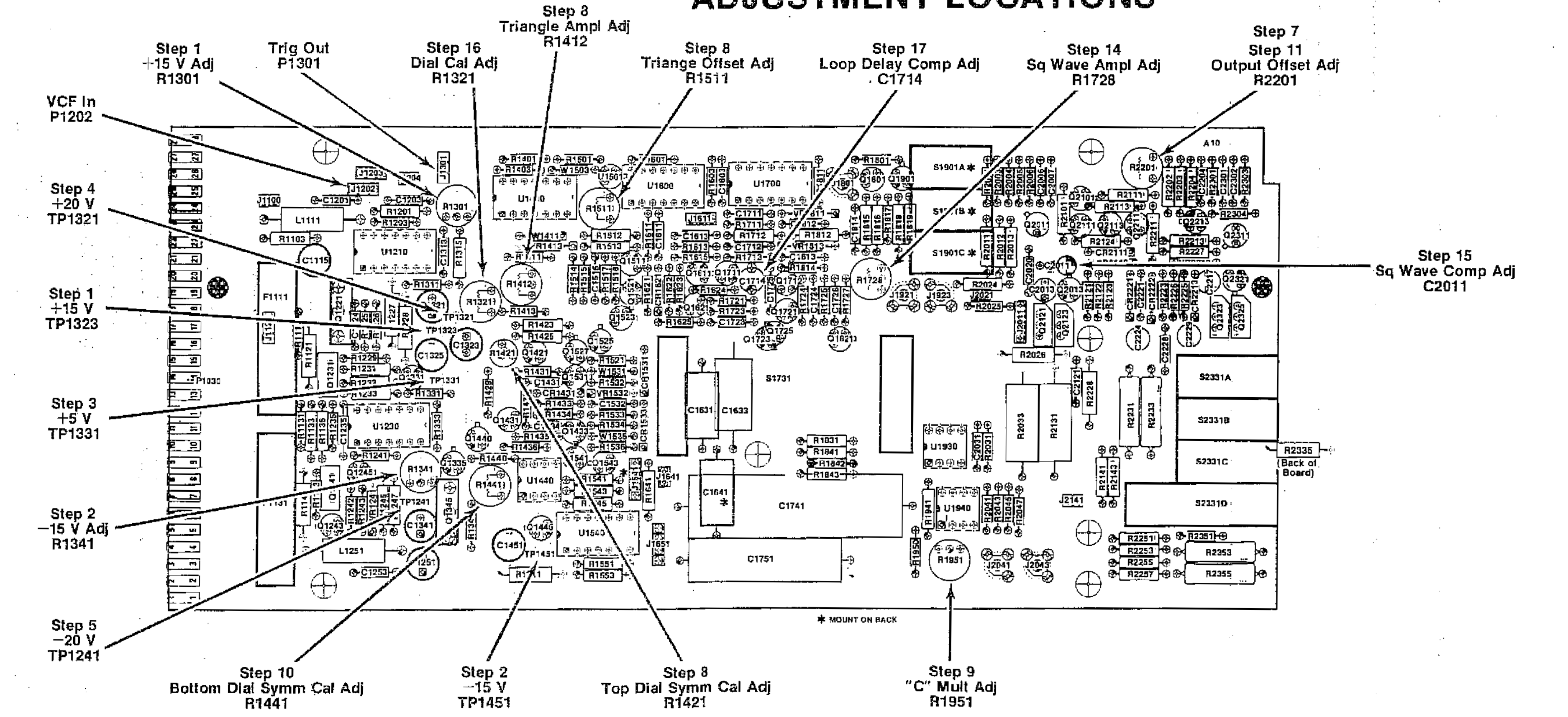
BLOCK DIAGRAM

Fig. 6-3.

2957-40

@

ADJUSTMENT LOCATIONS

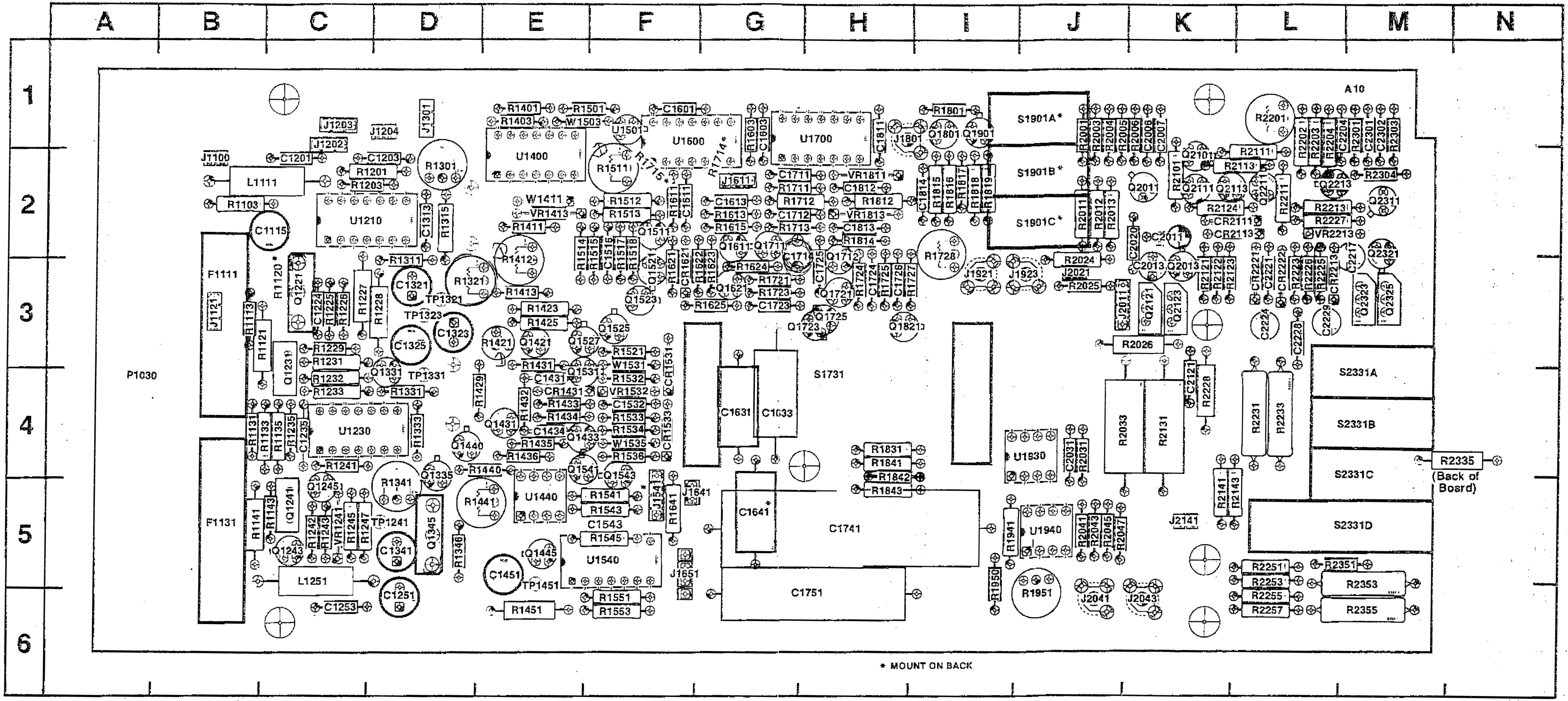


REV A JAN 1981

2957-13

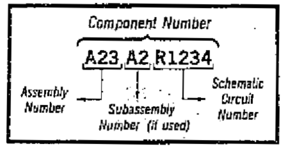
Fig. 8-2. Main Board.

PARTS LOCATION GRID



2957-15B

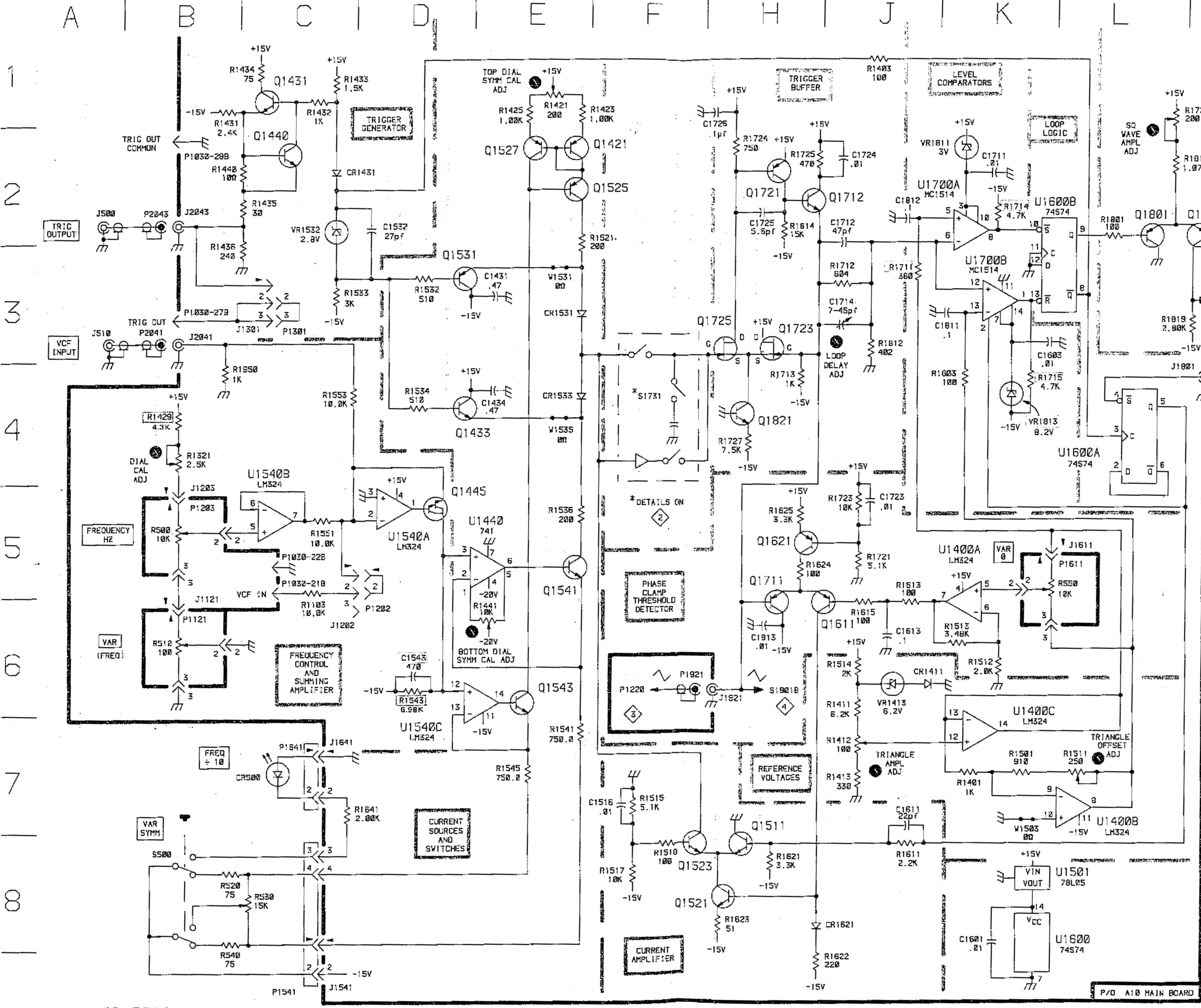
COMPONENT NUMBER EXAMPLE



Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

Static Sensitive Devices
See Maintenance Section

Fig. 8-4. Main Board (A10 Assy). REV MAR 1985



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS OUTLINED OR DEPICTED IN GREY.

Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE

Component Number
A23 A2 R1234
Assembly Number — Subassembly Number (if used) — Schematic Circuit Number

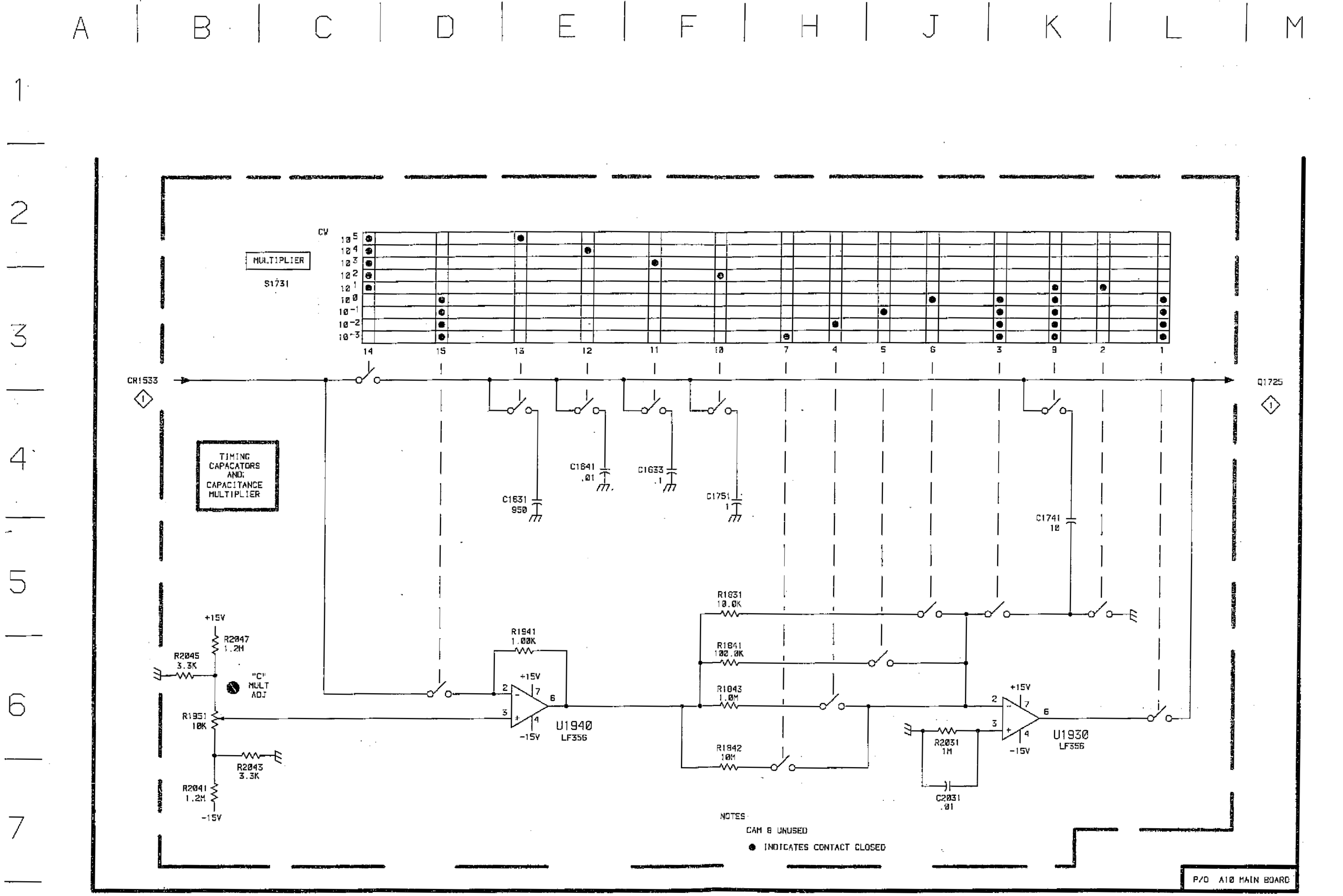
Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

FG 501A

LOOP

1

2957-35
REV JUL 1984



FG 501A

REV A JAN 1981

2957-36

CAPACITANCE MULTIPLIER

2

JS

PARTS LOCATION GRID

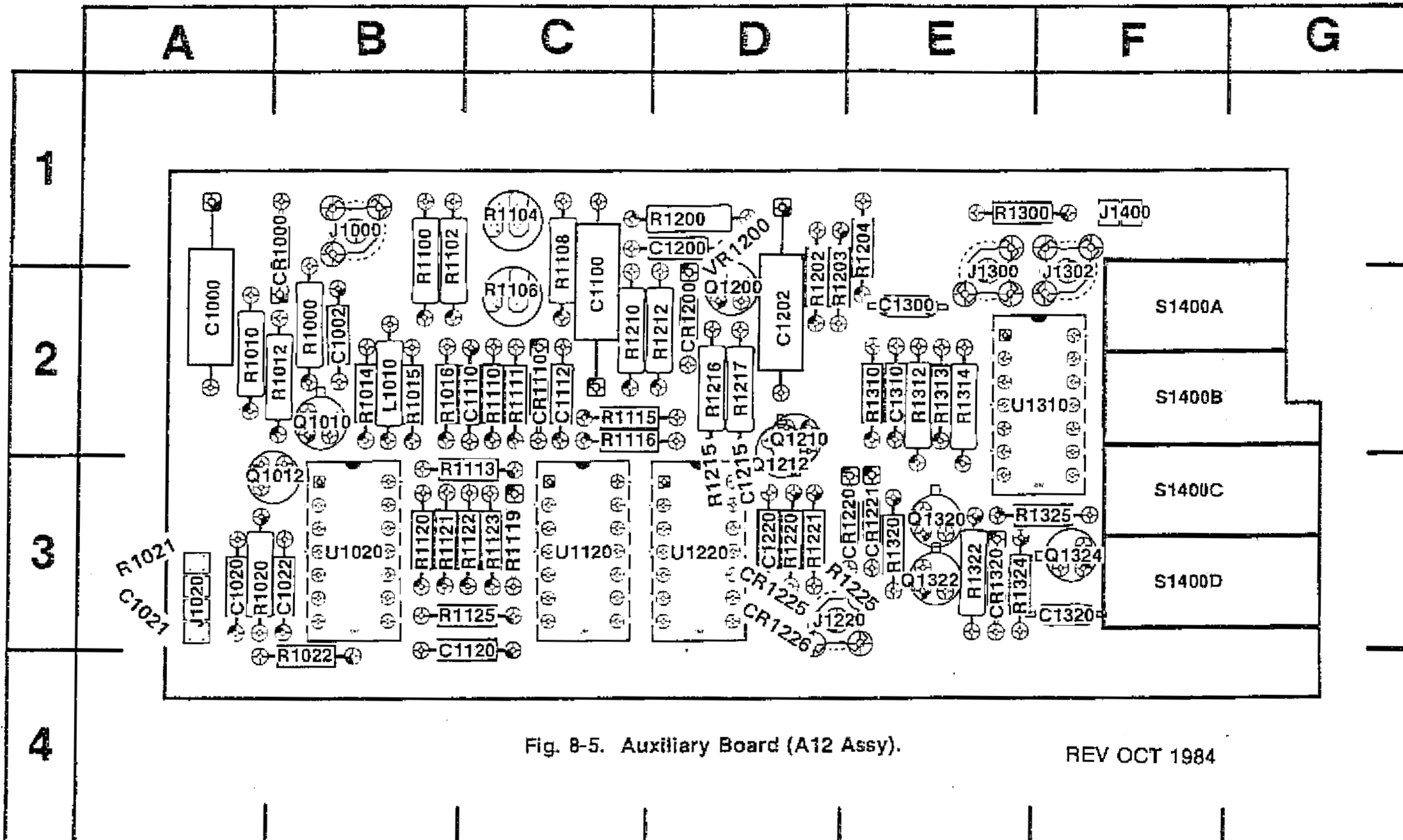
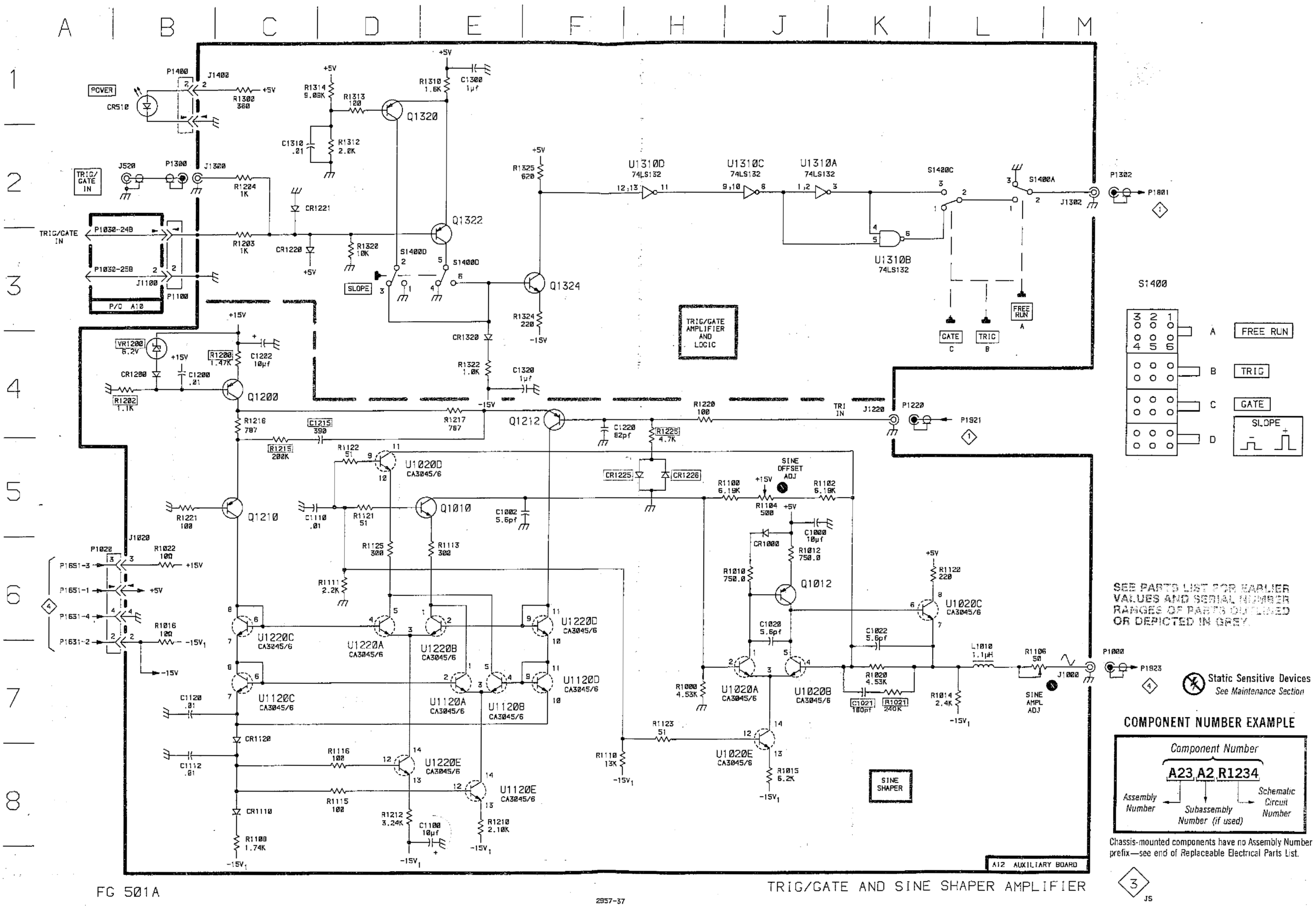


Fig. 8-5. Auxiliary Board (A12 Assy).

REV OCT 1984

2957-17B

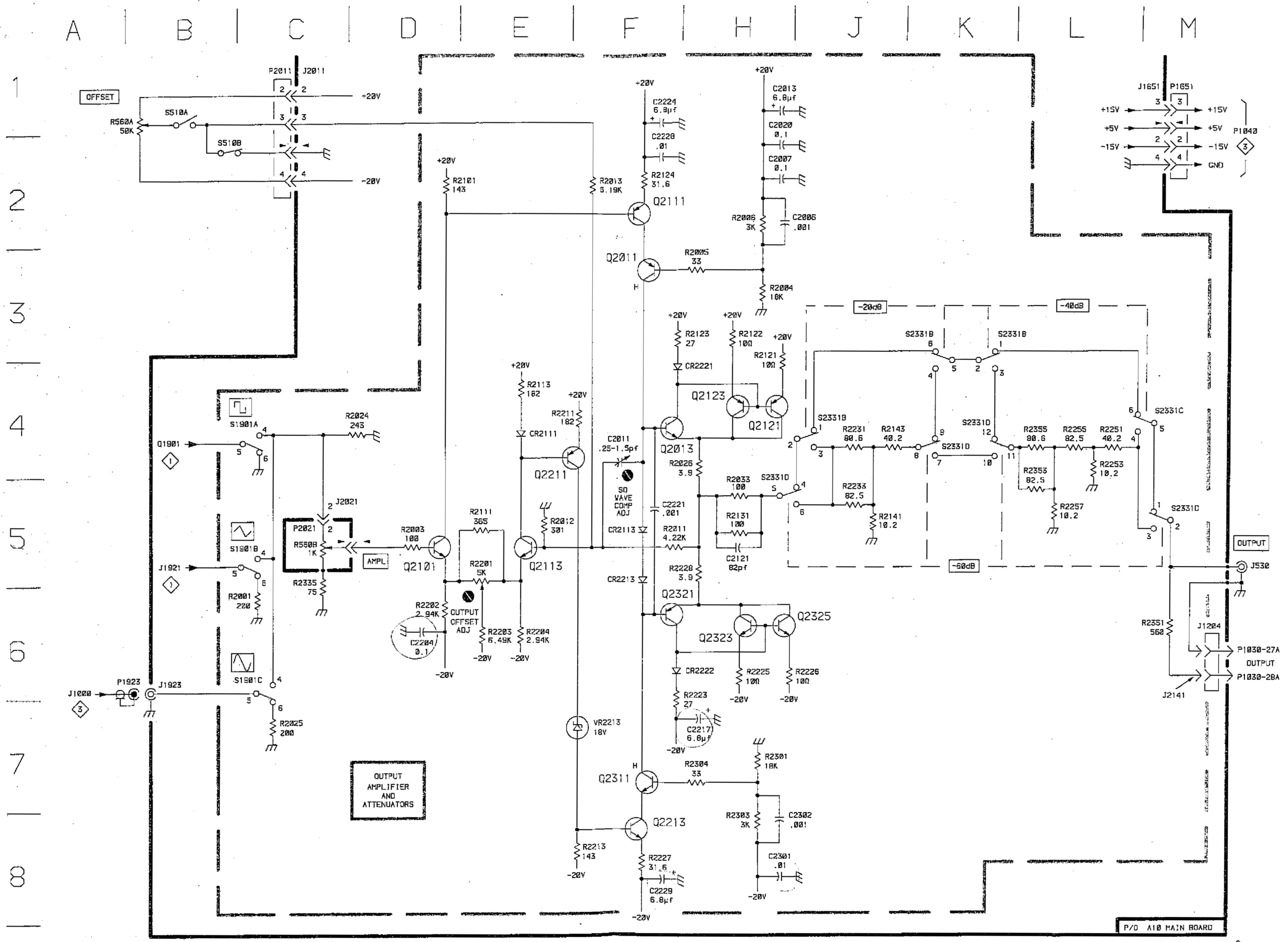


FG 501A

TRIG/GATE AND SINE SHAPER AMPLIFIER

2957-37

REV OCT 1984



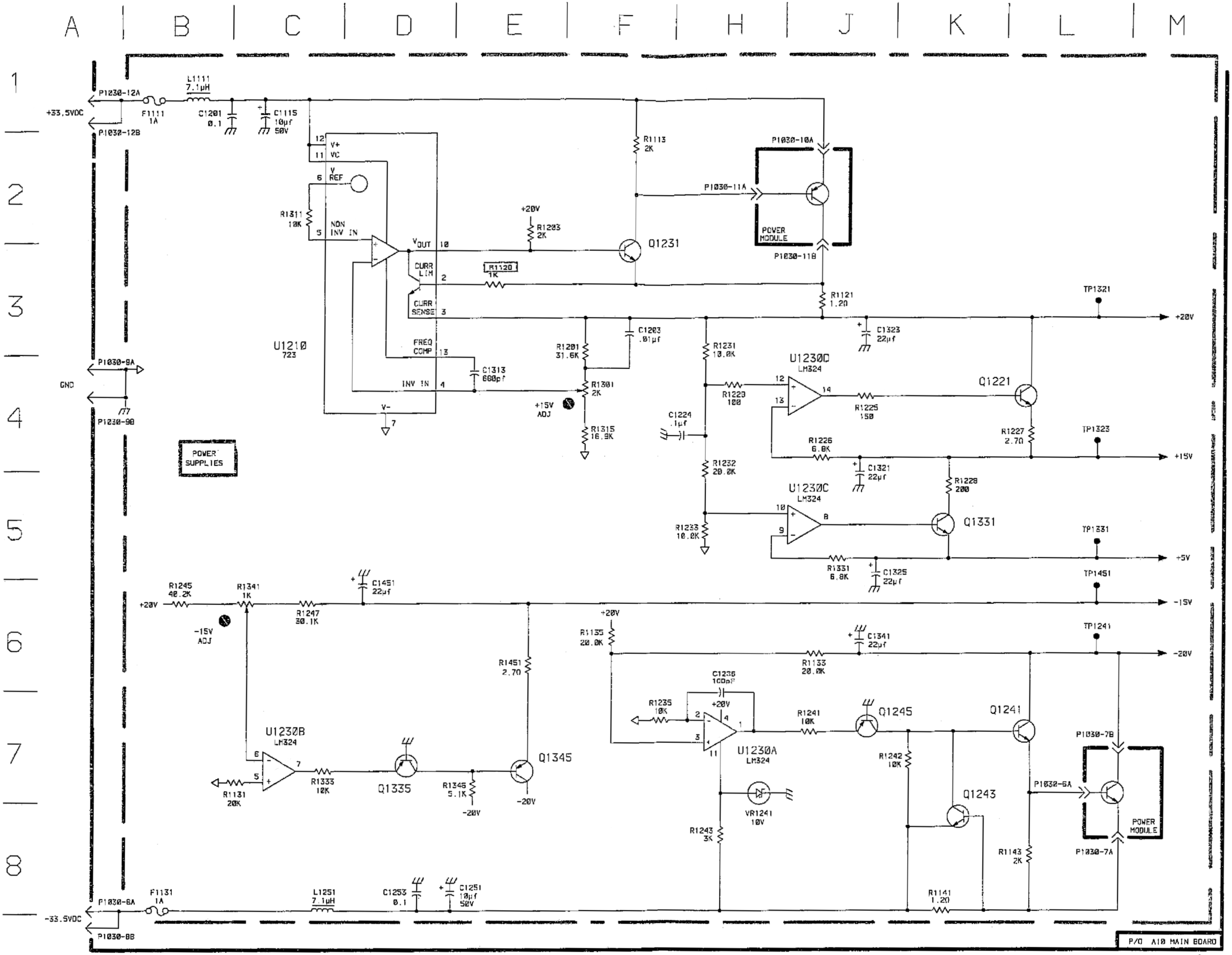
FG 501A

REV SEP 1981

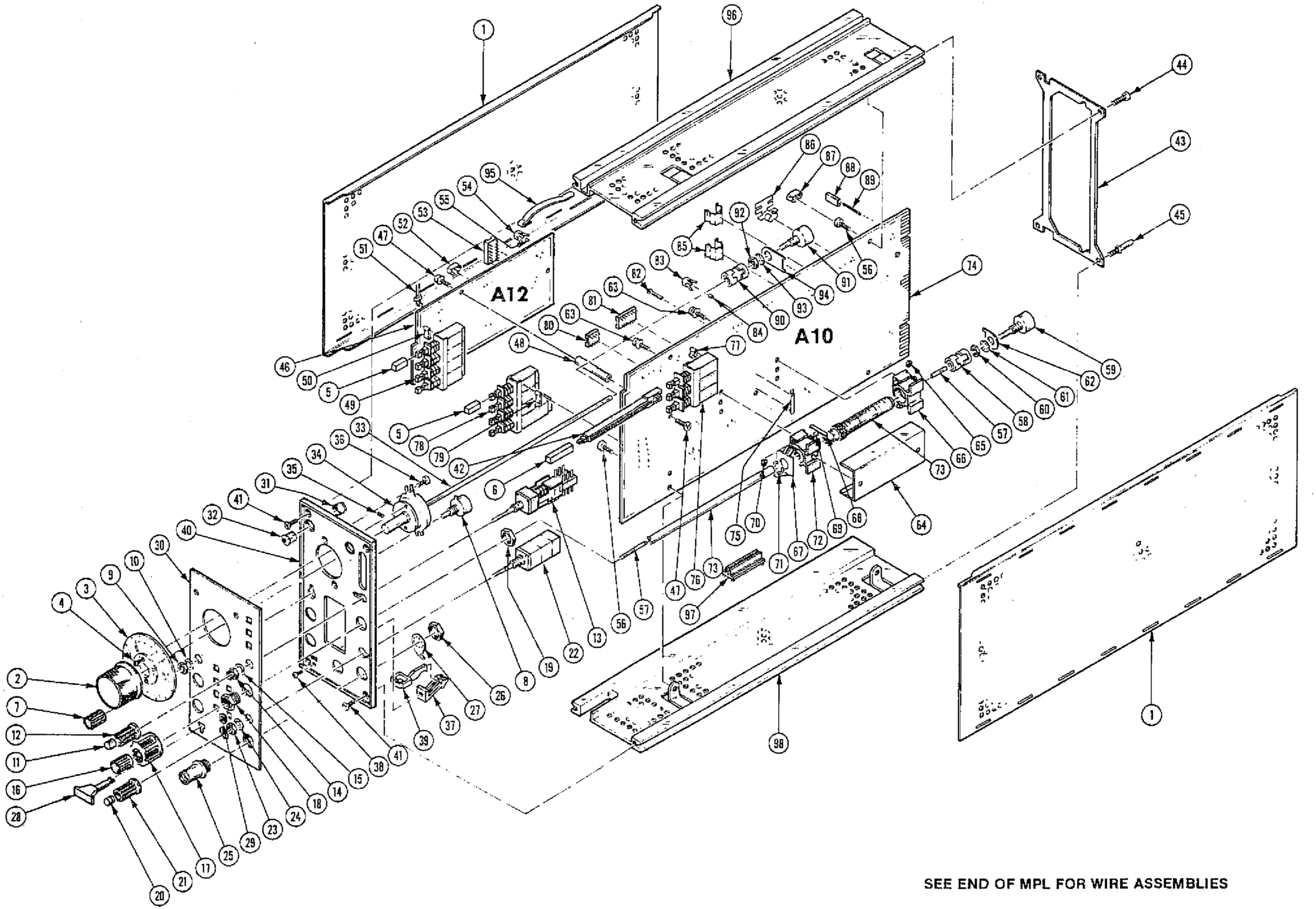
2557-38

OUTPUT AMPLIFIER AND ATTENUATORS 4

JS

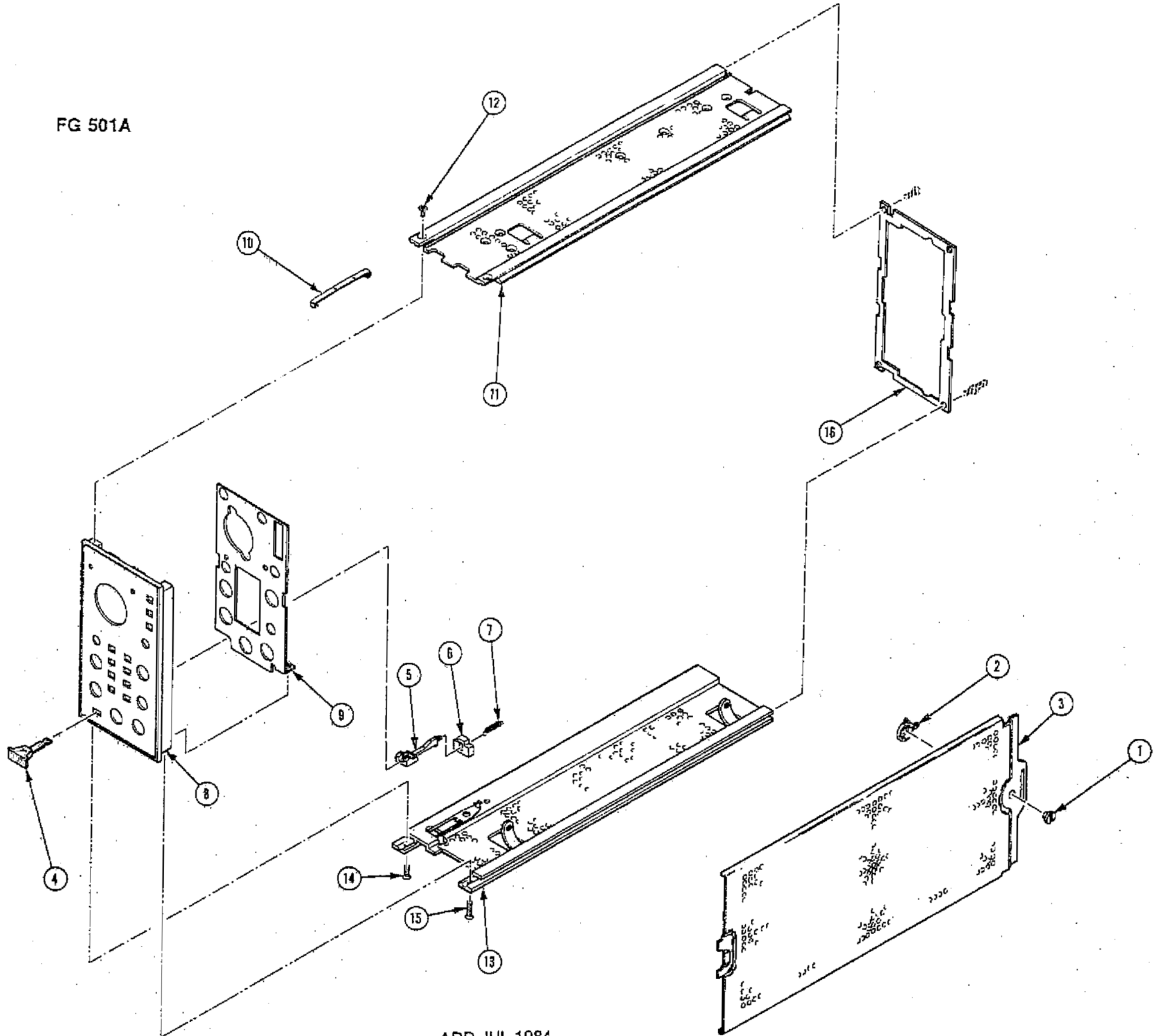


A B C D E F H J K L M
1 2 3 4 5 6 7 8
P1030-12A
+33.5VDC
P1030-12B
L1111 7.1µH
F1111 1A
C1201 0.1
C1115 10µf 50V
R1113 2K
P1030-10A
P1030-11A
POWER MODULE
P1030-11B
12 V+
11 VC
6 V REF
R1311 10K
5 NON INV IN
VOUT 10
CURR LIM 2
CURR SENSE 3
FREQ COMP 13
INV IN 4
V- 7
U1210 723
+20V
R1203 2K
Q1231
R1120 1K
R1121 1.20
TP1321
+20V
C1203 .01µf
R1201 31.6K
C1313 680pf
R1301 2K
+15V ADJ
R1315 16.9K
R1231 10.0K
U1230D LM324
R1223 100
R1225 150
Q1221
C1323 22µf
C1224 .1µf
R1227 2.70
TP1323
R1226 6.8K
+15V
C1321 22µf
R1228 200
R1232 20.0K
U1230C LM324
Q1331
R1233 10.0K
R1331 6.8K
C1325 22µf
TP1331
+5V
P1030-9A
GND
P1030-9B
POWER SUPPLIES
R1245 40.2K
R1341 1K
+20V
R1247 30.1K
C1451 22µf
-15V ADJ
TP1451
-15V
+20V
R1135 20.0K
C1341 22µf
TP1241
R1133 20.0K
-20V
R1451 2.70
C1236 100pF
R1235 10K
+20V
R1241 10K
Q1245
Q1241
U1230B LM324
U1230A LM324
P1030-7B
R1333 10K
Q1335
R1346 5.1K
Q1345
R1131 20K
-20V
-20V
R1242 10K
Q1243
P1030-6A
POWER MODULE
VR1241 10V
R1243 3K
R1143 2K
P1030-7A
P1030-8A
F1131 1A
L1251 7.1µH
C1253 0.1
C1251 10µf 50V
R1141 1.20
-33.5VDC
P1030-8B
P/O A10 MAIN BOARD



SEE END OF MPL FOR WIRE ASSEMBLIES

FG 501A



ADD JUL 1984